New Scientist

WEEKLY 18 January 2025

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SPECIAL REPORT

EARTH'S NEW CLIMATE

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New Scientist
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California's unprecedented wildfires

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Live long and prosper

Research into longevity and human well-being has exploded in recent years. But are longevity advocates selling snake oil or are there genuine interventions that will let us live longer? And can science really help you become more fulfilled? Join six experts on 8 February at London's Congress Centre to discover if science has the answers to a longer, healthier life.

newscientist.com/events

Tour

Arctic cruise: Svalbard, Norway

Explore the northernmost region of Earth, the realm of the polar bear and the midnight sun. Enjoy a full programme of shore visits and boat safaris, as well as talks from Richard Dawkins and oceanographer Russell Arnott on topics including glaciology, marine biology, astronomy and the history of polar exploration. This 12-day tour starts on 22 June and costs £14,395.

newscientist.com/tours

Podcast

Weekly

The team investigate the latest on H5N1 bird flu and the prospects of it becoming a human pandemic. Hear about the controversy around permanently gene-editing human embryos so that genetic changes would be passed on to future generations. Plus, some Italian physicists have found the most scientific way to make a classic pasta dish.

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SHUTTERSTOCK/DIEGO GRANDI

Rainforest recluse The mission to save Brazil's lowland tapirs

NASA/JPL-CALTECH

Rocks in a hard place How will NASA bring samples back from Mars?

Video

Tapir gardener

Watch an interview with Patrícia Medici, a world-leading expert on Brazil's lowland tapirs, large herbivores whose seed dispersal function is fundamental to rainforest ecosystems. "They're the gardeners of the forest," she says. Find out what Medici is doing to protect these animals, which are classed as vulnerable on the IUCN Red List of Threatened Species.

youtube.com/newscientist

Newsletter

Launchpad

The Perseverance rover has been collecting samples on Mars for several years. The plan was that these rocks would eventually be brought back to Earth to be studied in labs on the ground. *New Scientist* features editor Leah Crane considers why getting the samples back is proving tougher than expected.

newscientist.com/launchpad

Podcast

"If you gene-edit embryos, there's no margin for error because changes will end up in all body cells"

Gifts for all

The New Scientist Shop is packed full of products designed to spark curiosity and inspiration – perfect for turning January into an exciting adventure of learning and discovery. Whether you are interested in books or puzzles and games, this is a great way to challenge your mind.

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Breaking point

A confluence of climate events suggests weird and dangerous weather is here to stay

IF EVER there were a wake-up call, this is it. The fire alarm is ringing – hell, the fire alarm is on fire. The latest data confirms that 2024 was the first year in which the average global temperature was 1.5°C higher than pre-industrial levels, breaking a totemic limit set by the Paris Agreement (see page 8).

That this was completely expected makes it no less shocking. In January 2023, we reported that early modelling already suggested 2024 would be the first year to pass this threshold. What is unexpected, though, is just how much we may have breached 1.5°C by, with some datasets indicating the planet has actually shot straight through to 1.6°C.

It is time to accept the truth: we have broken the climate. From the drought and wind driving California's unprecedented January wildfires (see page 9) to the flailing and unpredictable jet stream (see page 32), climate systems are no longer behaving as expected, and the only thing we can say with certainty is that we should expect extreme weather events to become more frequent, stronger and longer-lasting.

"1.5°C itself doesn't matter – what counts is every fraction of a degree of warming we can stop"

The fact that confirmation of the 1.5°C breach comes in the same month that Donald Trump once more takes the mantle of US president is a double whammy. Under Trump, we can expect the US to roll back climate action, encourage fossil fuel development and, in some cases, ban renewable energy.

Is there any hope to be had? There are silver linings, albeit tarnished ones. Although a year above 1.5°C is a complete and utter global failure, it isn't a full violation of the Paris Agreement, which looks at temperatures on decade-long timescales. It is also true that, in some sense, the 1.5°C target itself doesn't matter – what counts is every tiny fraction of a degree we can prevent temperatures rising, not any specific limit.

And finally, we can find some hope in the fact that the world will eventually take climate change seriously – the only question is how many fires, floods and deaths it will take for us to get there. ▮

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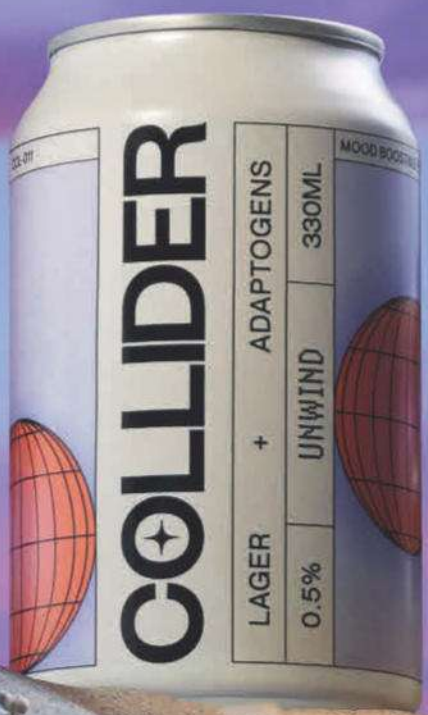

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DON PETTIT/NASA

Space

Visitor from outer space

This beautiful photo shows comet C/2024 G3 (ATLAS) flying near Earth, as seen by astronaut Don Pettit on the International Space Station on 11 January. It was first spotted by NASA's Asteroid Terrestrial-impact Last Alert System last year, when it was 600 million kilometres away. Its orbit around the sun takes 160,000 years, so we have a long wait before it returns.

Climate change

1.5°C breach confirmed

Last year was the hottest year in human history – and the first to pass 1.5°C above pre-industrial temperatures, says **Madeleine Cuff**

HOPES of keeping global warming below 1.5°C above pre-industrial levels have been all but lost, after new data confirmed 2024 was the first calendar year to see average temperatures breach that critical threshold.

Last year was the hottest ever recorded in human history, the World Meteorological Organization (WMO) declared on 10 January, in the latest warning that humanity is pushing Earth's climate into uncharted territory.

"This was a year when the impacts of climate change were seen right across the planet"

The average global temperature for the year was more than 1.5°C above the pre-industrial baseline for the first time, the agency also confirmed, temporarily breaching the threshold set by the Paris Agreement.

The WMO's assessment is calculated using the average global temperature across six datasets, with the period of 1850 to 1900 used to provide a pre-industrial baseline. Temperature datasets collected by various agencies and institutions around the world vary slightly, mainly due to differences in how ocean temperatures have been measured and analysed over the decades. Some of those come in just below the 1.5°C mark, but others are well above.

The UK's Met Office weather service puts 2024's average temperature at 1.53°C above pre-industrial levels, with a margin of error of 0.08°C. That is 0.07°C above 2023, the previous warmest year on record. Meanwhile, the European Union's Earth observation programme Copernicus has 2024 temperatures at 1.6°C above pre-industrial levels, 0.12°C above 2023's record.

Berkeley Earth, a climate research group in California, finds a rise of 1.62°C, the second time in its dataset that the rise in global average temperatures has breached 1.5°C, after 2023. Temperature data from NASA puts the rise in temperature a bit lower, at 1.47°C above pre-industrial levels, and the US National Oceanic and Atmospheric Administration finds a 1.46°C rise above pre-industrial levels. The WMO finds an average rise of 1.55°C across the six datasets, with a margin of error of 0.13°C.

Scientists agree that the surge in temperature was mostly due to the continuation of human-caused climate change and an El Niño weather pattern, which tends to push up global temperatures. But the scale and persistence of the heat has shocked many, who expected temperatures to subside once El Niño ended in May 2024. Instead, they remained at record levels for the rest of the year.

The world's oceans have been most affected, with sea surface temperatures staying at record levels for most of 2024, playing havoc with marine ecosystems. The year also brought no shortage of extreme weather on land, with fierce heatwaves, sharp declines in polar ice, deadly flooding and uncontrollable wildfires. "This was a year when the impacts of climate change are right across the planet," says David King, former chief scientific adviser to the UK government and founder of the Climate Crisis Advisory Group.

Technically, the Paris Agreement target of limiting warming to below 1.5°C is calculated using a 20-year average, so a single year above the threshold doesn't signal a formal breach of the target. But given the pace of warming in recent years, many scientists say the long-term Paris goal is now out of reach.

"The abrupt new records set in 2023 and 2024 join other evidence that recent global warming appears to be moving faster than expected," said Robert Rohde at Berkeley Earth in a statement. "Whether increased global warming is a temporary change or part of a new long-term trend remains to be seen. Already, though, the Paris Agreement target of staying below 1.5°C is unobtainable, and the long-term average will pass this milestone within the next five to 10 years."

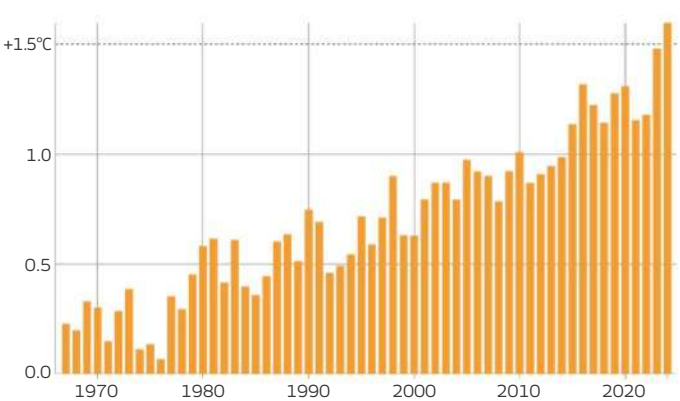
In a press briefing on 9 January, Samantha Burgess at Copernicus said that the Paris Agreement target was now probably impossible to achieve. "There's an extremely high likelihood

JOSEP LAGO/AFP VIA GETTY IMAGES

Reservoir levels in Catalonia, Spain, fell in 2024, exposing this once-submerged mill

Temperatures keep rising

The average global surface temperature has been increasing above pre-industrial levels (1850–1900). Last year was the first to pass 1.5°C



that we will overshoot the long-term average of 1.5°C and the Paris Agreement limit," she said.

Out of reach

Duo Chan at the University of Southampton, UK, has helped develop a new global dataset, DCENT, which he says uses state-of-the-art technology to produce a more accurate historical baseline for warming levels. This new dataset suggests that the global average temperature for 2024 was 1.66°C above pre-industrial levels, he says, although it isn't included in the WMO's calculations.

As a result, Chan also believes the 1.5°C goal is now probably out of reach. "We need to get prepared for a wider range of futures, and 1.5°C is not the only target we should be aiming for," he says. But he stressed this should also be a critical moment to be more ambitious in cutting emissions. "It's too early to give up," he says.

The outlook for 2025 is unclear. There are signs that global sea surface temperatures have started to cool to expected levels. "That's a good sign that the heat is dissipating from the surface of the ocean at least," said Burgess. Meanwhile, after months of expectation, a La Niña phase has developed in the equatorial Pacific Ocean, which should dampen global temperatures into 2025.

But Chan warns that the world may have experienced a step change in warming if temperatures follow the pattern of previous El Niño events. "Every time that we see a large El Niño event... global warming is basically brought up to a new level," he says, suggesting that 2024 could be the first of many years where average temperatures exceed 1.5°C. ▮

Additional reporting by James Dinneen

California wildfires fuelled by months of unusual extreme weather

FAST-MOVING wildfires in the Los Angeles area are burning out of control long after fire season normally ends in California. As *New Scientist* went to press, three fires were still burning (in Eaton, Palisades and Hurst), 100,000 people had been evacuated and 24 people had died.

The fires have been fanned by powerful Santa Ana winds. These aren't unusual for this time of year, but they have arrived after months of drought. The combination has led to a disastrous series of fires, in a possible indication of how climate change is shifting the way fires behave in the state.

"While Santa Ana fires are nothing new in southern California, this type of explosive fire event has never happened in January before, and it's only happened once in December," says Crystal Kolden at the University of California, Merced.

In the past week, more than 16,000 hectares (40,000 acres) have burned in the Los Angeles area, according to the California Department of Forestry and Fire Protection. The two largest fires are the Palisades fire and the Eaton fire. As *New Scientist* went to press, the Palisades fire was 13 per cent contained, with the Eaton fire at 27 per cent. The Hurst fire was 89 per cent contained. As well as costing lives and destroying homes, the fires have threatened NASA's Jet Propulsion Laboratory and the Getty Museum.

The strong Santa Ana winds reached speeds of up to 160 kilometres per hour last week, fanning the flames and driving their rapid spread. After reducing in speed over the weekend, the National Weather Service of Los Angeles issued a warning of further high winds of up to 113 kilometres per hour on 12 January.

This is the latest in a "very highly improbable sequence of extreme climate and weather events" that have contributed to the intense fires, says Park Williams at the University of California, Los Angeles (UCLA). The Santa Anas are a regular feature of southern California, but wet weather in autumn and winter usually limits their influence on fires. This year, that rainy weather still hasn't arrived, leaving vegetation dried out and ready to burn. Plus, there is more vegetation for fuel due to a wet winter in 2023 that boosted growth. Intense heat and drought throughout 2024 dried it out.

The combination of lots of fuel, drought and strong, hot, dry winds makes for "the most explosive fire behaviour imaginable", says Kolden.

"This type of explosive fire event has never occurred in January before, and only once in December"

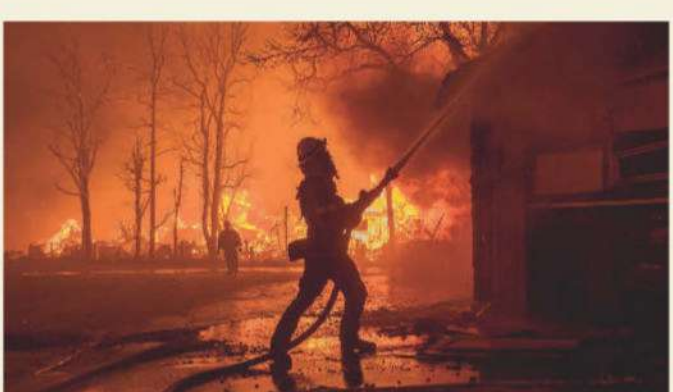
Officials are still investigating what ignited the blazes. Understanding the role that climate change may have played will also take some time. However, there is reason to think it has made the fires worse.

Above-average sea surface temperatures in the Pacific Ocean, probably driven in part by climate change, have also contributed to the dry conditions. According to Daniel Swain at UCLA, these higher ocean temperatures have created a ridge of high pressure that has blocked wet weather carried on the jet stream from reaching southern California.

The region has seen this kind of high-pressure weather system occur more frequently over the past 50 years, which may be a symptom of climate change, says Daniel Cayan at the University of California, San Diego.

James Dinneen

Firefighters battle the Eaton fire in Los Angeles on 7 January



DAVID MCNEW/GETTY IMAGES

Briefing

‘Mystery’ virus is anything but

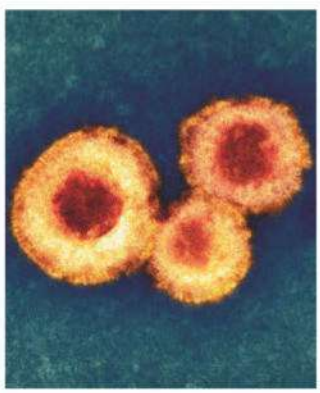
Reports of an infection spreading in China sound worrying, however it is a cold virus that almost all of us have had, says **Michael Le Page**

ALARMIST headlines that warn of China once again being overwhelmed by a mysterious new virus have dominated recently. But the germ reported to be responsible for the surge in respiratory infections, called human metapneumovirus, or hMPV, is actually neither mysterious nor new, and authorities in China have rejected claims that its health system is overwhelmed.

What is human metapneumovirus?
It is one of the many different viruses known as cold viruses because they infect the cells lining our respiratory tract, causing “common cold” symptoms that may persist for a few days, such as a sore throat, runny nose, coughing and sneezing. You have almost certainly had hMPV – studies of antibodies show that just about everybody gets infected by it by the age of 5. As with flu, people can be reinfected throughout their lives as immunity fades and new variants evolve.

How dangerous is hMPV?
In most people it only causes mild symptoms, but, like other cold viruses, it can occasionally be more serious and even deadly. Severe infections usually occur in people who are vulnerable for some reason, including very young children, older people and those with an impaired immune system or conditions such as asthma.

Globally, the virus is estimated to have killed at least 11,000 children aged under 5 in 2018. For comparison, another cold virus called respiratory syncytial virus, or RSV, is estimated to kill 60,000 children globally every year.



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Human metapneumovirus causes mild symptoms like a runny nose in most people

How long has hMPV been circulating in people?
It has probably been spreading in humans for centuries. The virus was first discovered in 2001, in samples taken from children in the Netherlands who had respiratory infections. Since then, it has been found in stored samples from as early as 1976, while antibodies to the virus have been found in blood samples from the 1950s.

Where did it come from?
Closely related viruses known as avian metapneumoviruses are known to circulate in birds and the human metapneumovirus is thought to have evolved from one of these. However, this is

“You have almost certainly had an hMPV infection – almost everyone has by age 5”

believed to have occurred around 200 years ago, so the situation with hMPV is very different to that with the covid-19 virus, which only jumped to humans in late 2019, meaning we lacked immunity to it.

While hMPV is now a human virus, it can also infect some other mammals, including chimpanzees and gorillas.

What kind of virus is it?
It belongs to a group called paramyxoviruses, which consist of a single strand of genetic material in the form of RNA enclosed in a protein coat. Other paramyxoviruses include measles and Nipah. The genome of hMPV is around 13,000 “letters” long and codes for just nine proteins, meaning it has a relatively small, streamlined genome, like many other respiratory viruses.

Is there a treatment or vaccine against hMPV?
There are no specific treatments for hMPV or any approved vaccines. However, potential vaccines are being developed. For instance, in 2024 a team at the University of Oxford began testing an mRNA vaccine designed to protect children against both hMPV and RSV.

Why are there so many cases in China at the minute?
It is normal for waves of cold and flu infections to occur during winter, and some years these waves are larger than others for reasons that aren’t well understood. More infections overall mean there will be more severe cases and therefore more hospital admissions.

“There’s nothing to indicate anything abnormal. So far, it looks like the normal endemic seasonal nasties doing what they do,” said Ian Mackay at the University of Queensland, Australia, in a blog post that noted there was a similar scare in 2023. ▮

Technology

3D-print your own working microscope in less than 3 hours

Karmela Padavic-Callaghan

THE world’s first fully 3D-printed microscope can be made in a few hours and for a fraction of the cost of traditional ones.

“It’s not just enabling, it’s empowering,” says Gail McConnell at the University of Strathclyde in the UK.

McConnell and her colleagues previously worked out how to 3D-print lenses like those used

DR LIAM M. ROONEY/UOS

This 3D-printed microscope cost less than £50 to create

in regular microscopes. For the body of the device, the team used a design from OpenFlexure, a publicly available resource for 3D-printing scientific instruments. Then, they added the 3D-printed, clear plastic lenses they designed, a store-bought camera and a light source, all of which were controlled by a Raspberry Pi computer processor (bioRxiv, doi.org/n2d8).

Traditional microscope lenses often cost hundreds of pounds, and full microscopes can run to thousands, but this one cost less than £50 to create. Without the added camera and the processor, the microscope weighs as little as 3 kilograms, says Liam Rooney, also at the University of Strathclyde.

It is a relatively fast process, too. “Within 3 hours, you go from having a computational design that you’ve downloaded from the internet to having a working optical microscope,” says Rooney.

The researchers tested it by examining a blood sample and a thin section of a mouse kidney and found they could see enough sub-cellular and anatomical detail that it could be useful for diagnosis. ▮

Quantum computing

Quantum computer is first to correct its own errors

Karmela Padavic-Callaghan

A TINY cooling device can automatically reset malfunctioning components of a quantum computer. Its performance suggests that manipulating heat could also enable other autonomous quantum devices.

Quantum computers aren't yet fully practical because they make too many errors. In fact, if qubits – key components of this type of computer – accidentally heat up and become too energetic, they can end up in an erroneous state before the calculation even begins. One way to reset the qubits to their correct states is to cool them.

Simone Gasparinetti at Chalmers University of Technology in Sweden and his colleagues have delegated this task to an autonomous quantum "refrigerator" for the first time. The researchers built two qubits and one qutrit, which can store more complex information than a qubit, from tiny superconducting circuits. The qutrit and one of the qubits formed a fridge for the second target qubit, which could eventually be used for computation.

The researchers carefully engineered the interactions between the three components to ensure that when the target qubit had too much energy, which caused errors, heat automatically flowed out of it and into the two other elements. This lowered the target qubit's temperature and reset it. Because this process was autonomous, the qubit-and-qutrit fridge could correct errors without any outside control (*Nature Physics*, doi.org/n2fb).

Aamir Ali, also at Chalmers University of Technology, says this approach to resetting the qubit required less new hardware than more conventional methods – and yielded better results. Without any significant quantum computer redesign or introduction of new wires, the qubit's starting state was correct 99.97 per cent of the time. In contrast, other reset methods typically only manage 99.8 per cent, he says.

"The fact it is autonomous, so it doesn't need external control, should make it efficient and versatile"

This is a powerful example of how thermodynamic machines – which deal with heat, energy and temperature – can be useful in the quantum realm, says Nicole Yunger Halpern at the National Institute of Standards and Technology in Maryland, who worked on the project.

"It's nice to see this machine implemented and useful. The fact that it is autonomous, so it does not require any external control, should make it efficient and versatile," says Nicolas Brunner at the University of Geneva in Switzerland.

Michał Horodecki at the University of Gdańsk, Poland, says one of the most urgent problems for quantum computers built with superconducting circuits is making sure the machines don't heat up and so make errors. The new experiment opens a path for many similar projects that have been proposed but never tested, such as using qubits to build autonomous quantum engines, he says.

The researchers are already looking into whether they could build on their experiment. For example, they might create an autonomous quantum clock or design a quantum computer with other functions automatically driven by temperature differences. ▮

Palaeontology

Punk and Emo rock our ideas of ancient molluscs

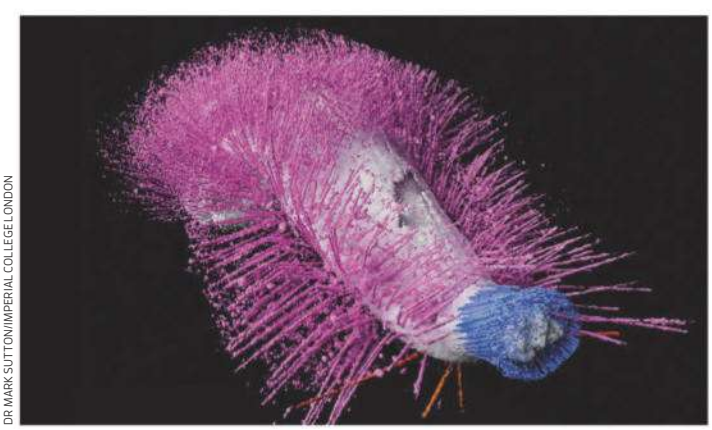
FOSSILS of two prehistoric marine molluscs with distinctive spiky "hairstyles" have been discovered and named Punk and Emo.

Their strange appearance highlights the ancient diversity of molluscs – which nowadays include organisms like snails, slugs, clams and octopuses.

"Some people may be a bit down on molluscs. My partner called them loser animals. But they're one of the really major branches of life," says Mark Sutton at Imperial College London.

He and his team unearthed the finds, which date back 430 million years, at a UK site known as the Herefordshire Lagerstätte.

The fossils, from a group of molluscs known as Aculifera, were so delicate that the researchers couldn't just crack open the stone that contained them because that would destroy their fragile forms.



DR MARK SUTTON/IMPERIAL COLLEGE LONDON

Spikes on the *Emo* mollusc, shown here as a model, may have been for protection

Instead, they used X-ray scans to discern the structures inside the rock and then took thin slices of the material, photographing each layer and then putting the images together to create a 3D picture of what the organisms looked like.

Both species were worm-like, about 2 centimetres long and with lengthy spines (*Nature*, doi.org/n2fc).

The music-related monikers were originally pet names, says Sutton, because the spike-laden fossils were reminiscent of hairstyles from the punk rock movement, but the names stuck, leading to the official suggestions of *Punk ferox* and *Emo vorticaudum*.

"The spikes are probably mostly protective," says Sutton, although it is possible that they were formed because the organisms needed to get rid of calcium that accumulated in their bodies as they went about life in the sea. ▮

Chris Simms

Space

Campaign to keep space tidy

Adding space junk to the UN's development goals may help unclutter our surroundings

Jonathan O'Callaghan

THE rising threat of space junk should be tackled by a new global agreement to safeguard Earth's orbit, say a group of researchers who are calling for the United Nations to make the protection of space a key international goal.

Although there are existing guidelines to tackle space debris, such as the UN Outer Space Treaty of 1967, the researchers call for further action to "increase awareness about the use of orbital resources and the growing risks of orbital pollution, whilst sending a strong message that Earth's orbit is not disconnected with Earth" (*One Earth*, doi.org/n2fk).

The team proposes that the protection of space be added to the UN's existing sustainable development goals (SDGs), which are 17 broad objectives set for member states to achieve by 2030. These include eradicating poverty, promoting gender equality and tackling climate change. "They were set up to provide a sustainable future," says team member Heather Koldewey at the Zoological Society of London. "But there is nothing for space."

To rectify that, the researchers want to add an 18th SDG, with pledges that include ensuring satellites and rockets are removed from orbit at the end of their life to prevent collisions and the creation of new debris, and the introduction of fines and legislation to ensure accountability. "We know from the oceans that removing debris once it's there is extremely challenging," says Koldewey.

An illustration of the space junk that orbits Earth, including defunct satellites

MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY

"We want to avoid the same thing happening in space."

The number of active satellites in orbit has rocketed in recent years, from fewer than 3000 in 2020 to more than 10,000 today. The bulk of that increase is down to around 7000 satellites that make up SpaceX's Starlink space internet mega constellation. On top of this, there are thousands of empty rockets orbiting Earth as well as millions of pieces of space junk.

Including space debris in an 18th SDG could raise the profile of the issue, says Christopher Newman at Northumbria University, UK. "Anything that raises awareness of space debris has got to be a good thing," he says.

Hugh Lewis, a space debris expert at the University of Southampton, UK, says that creating an SDG focused on space would be a "worthwhile endeavour". However, he adds that there are already mechanisms to tackle space debris, like the UN's long-term sustainability goals for outer space activity and more localised action, such as in the US, where the Federal Communications Commission has introduced a five-year rule to remove dead satellites from orbit. "It's difficult to argue that it's not already on the UN agenda," says Lewis.

The elephant in the room is that nothing meaningful can happen without the agreement of SpaceX and its owner, Elon Musk. "You cannot talk about space governance without talking about them now," says Newman. "We can't just look at member states any more." ▮

Physiology

Tissue in your ear and nose looks like bubble wrap

A LONG-overlooked skeletal tissue found in the nose and ears turns out to resemble bubble wrap – and harnessing it could make facial surgery, like nose reshaping, easier.

Maksim Plikus at the University of California, Irvine, and his team first spotted the unusual tissue a few years ago while they were studying fat cells collected from mouse ears. "It was just a scientific accident," he says.

The nose and ears of both mice and humans contain a firm but flexible tissue called cartilage, which is also found in our joints. Conventional wisdom says that cartilage is structured similarly, no matter where it is in the body. The cells in it don't contain much fat and are surrounded by a thick, protein-rich matrix that provides strength.

But when the researchers examined mouse nose and ear samples under a microscope, they found a structure consisting of cells packed full of fats, also known as lipids, connected only by a thin mesh of protein – prompting the team to name it lipocartilage. "It looks like bubble wrap," says Plikus.

This unusual cartilage had been noticed before, the team found, but only in a brief account of its discovery from the 1850s and a few short reports since then.

To investigate it, the researchers stretched and squeezed samples of lipocartilage from mouse ears, and did the same for cartilage from the knees and ribs of mice. They found that lipocartilage is softer and more stretchy, probably due to its high fat content, says Plikus.

"The unusual cartilage is softer and more stretchy, probably due to its high fat content"

The researchers also found lipocartilage in human ear and nose samples, leading them to wonder whether the tissue could be grown in the lab for use in reconstructive or cosmetic surgery. They were able to grow it from human stem cells derived from embryos (*Science*, doi.org/g8x7rs). Plikus's team is already carrying out facial implant tests with stem-cell derived lipocartilage in mice and hopes to trial it in humans soon. ▮

Carissa Wong

Botany

Tomato plants are covered in tiny anti-pest booby traps

Karmela Padavic-Callaghan

FOR hungry insects, walking along a tomato stalk in search of a meal can be like navigating a minefield.

Jared Popowski at the University of Amsterdam in the Netherlands was trying to gauge the mechanical properties of tomato plants in the lab. Then a tiny hair on one of the stalks started oozing liquid – and it happened so quickly his camera barely caught it. He had inadvertently triggered one of the plant's pest-protection mechanisms.

To learn more about how these liquid-filled hairs, called glandular trichomes, work, Popowski and his colleagues created force sensors made with thin glass. Across 84 measurements, the mean force needed to rupture a trichome was less than 10 micronewtons. Once the trichome's bulbous top ruptured, it took less than a millisecond to release liquid.

This liquid was too viscous to spray into the air, says Popowski. Instead, it formed a droplet that could stick to an insect. As an insect walks through a forest of trichomes, it will accumulate droplets, become increasingly wet and slow down, preventing it from eating the plant.

The team recorded this process on camera with nymphs of the Western flower thrips (*Frankliniella occidentalis*), which are a common pest of tomato plants (arXiv, doi.org/n2f3).

Eduardo de la Peña at the Spanish National Research Council says this detailed understanding of the tomato's defences could be useful for developing pest management strategies. For example, we may not need to target pests big enough to trigger trichome rupture, as the plant already has "natural weaponry" against them, he says.

Wild tomato plants have more trichomes than cultivated ones, so breeding between the two could add more natural defences to commercially grown varieties. ▮

Analysis Gene editing

Will genome editing transform our children's health?

Claims that we could slash the risk of health conditions by editing genomes of embryos are controversial, finds **Michael Le Page**

ADAM ANGELIDES/GETTY IMAGES

Genome editing could give the next generation a lower risk of many conditions

THE risk of developing many common health conditions could be drastically reduced by making dozens of edits to people's genomes at the embryo stage, claims a team of biologists and ethicists. We don't yet have the technology to do this safely, but we should start thinking about whether to use it when we do, they say.

However, their paper has come under fire from other biologists, who say we know too little to predict the effects of this editing with any certainty and that making "incredibly speculative" claims is irresponsible.

"It's going to be taken up by people who are pushing a eugenics agenda in an unsophisticated way," says Kevin Mitchell at Trinity College Dublin in Ireland, who, with others, has written a critique of the paper.

Genomes continually mutate, so there is a huge amount of variation in the human population. A few variants or mutations are clearly harmful, causing inherited conditions such as cystic fibrosis.

The effect of most variants is much less clear, however. To investigate, biologists look for links between particular variants and the risk of, say, heart disease.

These studies have revealed variants that appear to reduce the risk of certain conditions. The most common only have a tiny effect, but some rare protective variants have a bigger impact. For instance, some people have much lower cholesterol levels due to variants in a gene called *PCSK9*.

Peter Visscher at the University of Queensland in Australia and his colleagues have now estimated the potential benefits of using genome editing to give individuals dozens or even hundreds of rare variants that each has a relatively large protective effect. This editing would be done at the embryo stage so every cell in the body inherits the edits and they are passed down to any children.

60-fold

Drop in prevalence of type 2 diabetes with 10 genome edits

According to their estimates, making around 10 edits to embryos could cut the prevalence of type 2 diabetes up to 60-fold. A different 10 edits could reduce the prevalence of heart disease up to 30-fold, Alzheimer's disease nearly tenfold, and so on.

Making 40 changes at once could reduce an individual's lifetime risk of developing Alzheimer's, schizophrenia, type 2 diabetes and heart disease to less than 0.2 per cent for each condition (*Nature*, doi.org/n2dm). "People tend to underestimate the potential power of [this type of] gene editing," says Visscher.

It currently isn't possible to safely make so many changes at once. But Visscher and his colleagues think this will become possible within three or so decades, so we should start thinking about whether, and how, to use it now.

But there are problems with the team's estimates, says Mitchell. For example, these rare variants might be rare because they protect against one condition but increase the risk of others. "It overlooks the glaring fact that these may be rare for a reason," he says.

Also, association studies cannot reveal which variants are the direct cause of the effects they are linked to – it is like being able to link a gang to a series of murders but not being sure which individual pulled the trigger.

Visscher and his colleagues do acknowledge these limitations in their paper and also discuss the many ethical issues, but Mitchell thinks they don't go far enough. "These sort of simplistic models are simply not warranted when it comes to making predictions about individuals where you're going to make an intervention and you have a responsibility to do no harm," says Mitchell. ▮

Physics

‘Impossible’ particles may be real

Paraparticles, which fall outside our standard classification of the building blocks of nature as either fermions or bosons, could be detectable after all, says **Alex Wilkins**

A GROUP of fundamental particles, long theorised but thought to be physically impossible, might exist after all. Known as paraparticles, they could one day have exotic applications – if we ever manage to detect them.

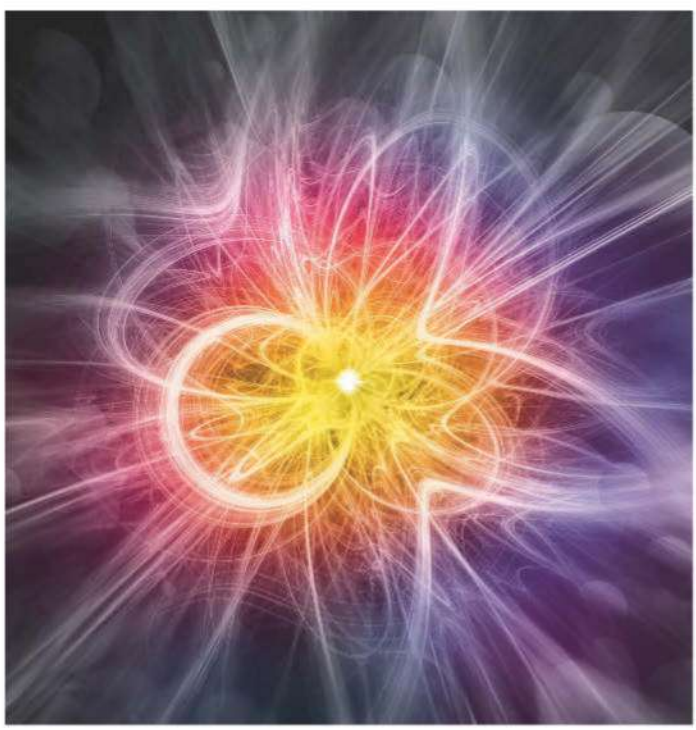
Paraparticles aren’t a new idea, but physicists have previously dismissed them as having no relevance to physical reality. The concept has its origin in a division between the known fundamental particles that are always classified as belonging to one of two groups, either a fermion or a boson.

The difference comes down to what happens when two particles in the same group swap places. Exchanging bosons, such as photons, doesn’t alter their quantum wave function, which is a complete mathematical description of their properties. But swapping two fermions, for example electrons, turns their wave function negative.

This seemingly simple difference has profound physical consequences. It means that an infinite number of bosons are allowed to occupy the same space – the principle by which lasers work, where many photons can pile up and create extremely high energy densities. By contrast, fermions must always remain separated in space, which is what keeps neutron stars stable.

Beyond negative

In the 1950s, British physicist Herbert Green put forward a more complicated model of particle swapping, called parastatistics, where the quantum wave function can be altered in ways other than turning negative. Green showed that this implied many new classes of particles could exist, which he called parabosons and parafermions. These would allow only a certain number of particles to exist in the same state, rather than just one or infinitely many. But physicists that examined the idea more closely found that these paraparticles wouldn’t function in detectably different ways from fermions or bosons, rendering the concept seemingly irrelevant.



GIROSCIENCE/SCIENCE PHOTO LIBRARY

Parafermions and parabosons were first suggested in the 1950s

Now, Zhiyuan Wang and Kaden Hazzard at Rice University in Texas have found that paraparticles could be physically detectable. “Our paper proves, for the first time, that there is actually something beyond fermions and bosons,” says Wang.

The duo first came up with a new mathematical description of paraparticles, which included stricter rules than previous definitions, such as making sure that information couldn’t travel faster than light. They then showed that there were specific quantum systems where these paraparticles should emerge as vibrations and be physically detectable (*Nature*, doi.org/g8x4zk).

“It’s a very daring thing, because everybody will take the folklore that parastatistics are not physical and they will work with that and bypass the topic,” says Jiannis Pachos at the University of Leeds, UK. “But these guys went back to it and they proved they are possible to exist, which is fantastic.”

> **“There are specific quantum systems where paraparticles should emerge”**

Not everyone is convinced, though. “It’s an interesting observation, but it’s not clear how easy this will be to realise in nature,” says Paul Fendley at the University of Oxford.

Observing these particles would require advances in our ability to control quantum states that are probably many years away, he says. “It’s a proof of principle, but the principle doesn’t cover anything, at least at the moment, close to reality.”

Another dimension

One limitation of the new work is that the pair have so far only shown that paraparticles can exist in one or two dimensions, though there is nothing ruling out their existence in three. Another wrinkle is that the paraparticles Wang and Hazzard propose are technically quasiparticles, which, as the name suggests, aren’t fundamental particles like electrons or photons, but are instead collective vibrations acting as if they were a particle.

Wang and Hazzard also speculate that paraparticles could exist as fundamental particles because the maths doesn’t rule it out, but they don’t have any concrete evidence to show where or how they might show up.

It isn’t clear whether these paraparticles, if they are ever observed, would have a practical use, but hints they could come from another kind of quasiparticle observed in two dimensions – the anyon. It turns out this might be useful for quantum computing systems because of its unique property that it has a memory of its swapping behaviour.

“We don’t have an obvious application [for paraparticles] at the moment, it’s just something exciting and exotic, but that has proven in the past to be a good enough reason to invest research in it,” says Pachos. ▮

Health

Gene-edited cells show promise for treating type 1 diabetes

Michael Le Page

THE first human trial of insulin-producing cells that have been gene-edited to evade immune attack is a success so far. The cells have made insulin for a month after being injected into a 42-year-old man with type 1 diabetes.

As a precaution, only a small number of cells were injected into a forearm muscle, so the man still needs insulin injections. It also remains to be seen how long the cells survive. Nonetheless, the results are promising, said Per-Ola Carlsson at Uppsala University Hospital in Sweden, where the trial was done, in a statement. "[The findings] provide real hope that a scalable, curative treatment for patients with type 1 diabetes... is possible."

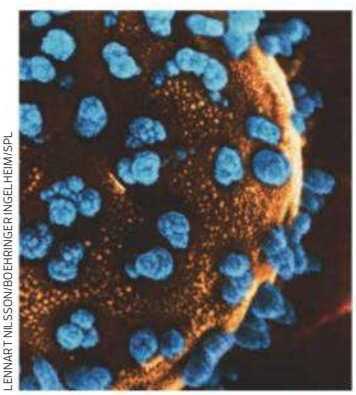
"The edited cells were protected from the man's autoimmune response and from rejection as foreign"

Beta cells in the pancreas normally regulate blood sugar levels by releasing the hormone insulin when blood sugar levels rise. But in people with type 1 diabetes, the immune system attacks and kills beta cells. The condition is deadly unless treated by regularly injecting insulin.

The transplantation of beta cells taken from dead donors became an approved treatment in 2023, but recipients have to take drugs to suppress the autoimmune response that killed their own beta cells, as well as to prevent the donor cells from being attacked as foreign. These drugs can also have serious side effects.

One way to avoid immune suppression is to transplant beta cells encapsulated in containers with holes so small that they keep out immune proteins and cells. This has worked for a few months in human trials, but then the holes gunk up and the beta cells die.

Seattle-based Sana Biotechnology is instead gene-editing cells so they can evade the immune system. Two edits block the production of the HLA1 and HLA2 proteins, which protrude from the outside of cells and allow the immune system to recognise the cells as self or foreign. Because the immune system also kills any cells that lack HLA proteins, a third edit boosts levels of the protein CD47, which acts as a "don't kill me" sign on the outside of cells.



LENNART NILSSON/BOEHRINGER INGELHEIM/SPL

Beta cells in the pancreas release insulin (blue)

The initial results confirm that beta cells with these edits were protected from the man's autoimmune response against beta cells and from rejection as foreign cells, says Michael Rickels at the University of Pennsylvania. In principle, injecting a higher number of cells should eliminate the need for insulin injections.

"This is a major step towards the eventual goal of beta-cell replacement therapy for type 1 diabetes without the need for immunosuppression," he says.

One downside of this approach is that if any of the modified cells turn cancerous, the tumours would go undetected by the immune system. The cells were injected into the forearm because it is easier to spot any problems.

In tests in animals, Sana has shown that the modified cells could be killed off by injecting an antibody that targets CD47. "This provides an additional safety measure should a problem develop," says Rickels. ▮

Psychology

Parents feel less disgust once babies start eating solids

PARENTS aren't easily disgusted, but only once their child has started eating solids. Changing disgust levels over time could have evolved to both protect the child and prime their immune system.

Disgust probably evolved as a way to avoid pathogens, such as those in faeces. Edwin Dalmaijer at the University of Bristol, UK, was curious about how parents tolerate dirty diapers, or nappies, when he became a father. "That's obviously an ideal natural experiment, where you're faced with a lot of disgusting nappies," he says. "What does that do to your disgust habituation?"

SHUTTERSTOCK/PIKSELSTOCK

Changing dirty diapers alters your disgust habituation

He and his colleagues recruited 99 parents and 50 non-parents, aged 18 to 73, in the US and the UK. Nearly half of the parents had nappy-wearing babies, with most changing at least two nappies a day.

The participants completed a disgust scale – ranking their reactions to things like seeing a cockroach – and answered questions on parenting-related concepts, like changing nappies close to dinner. Next, the researchers measured how long participants looked at a repulsive image, such as soiled nappies, versus a more neutral one.

They found that the parents of weaned babies were less easily disgusted than non-parents and parents whose babies were still only consuming milk (PsyArXiv, doi.org/n2f4). "It looks like the constant barrage of bodily effluvia that emanates from their children just presents them with such a disgust experience that seems to be associated with reduced disgust avoidance," says Dalmaijer.

The parents of not-yet-weaned babies were more easily disgusted than non-parents. This could help protect younger babies from germs, says Dalmaijer. The acceptance of disgusting substances post-weaning might allow for a slight drop in parents' protective barriers, which could help to prime a child's immune system, he says. ▮

Christa Lesté-Lasserre

Analysis Social media

Are tech firms giving up on policing their platforms?

Facebook's owner Meta is joining X in switching to crowdsourcing to moderate its content – but will it work, asks **Chris Stokel-Walker**

HAS the battle for content moderation, long one of the thorniest problems facing social media companies and other online platforms, finally been lost? A new move by Meta suggests so.

"We're going to get back to our roots and focus on reducing mistakes, simplifying our policies and restoring free expression on our platforms," said Meta CEO Mark Zuckerberg in a video statement published to his Facebook page. This means getting rid of fact-checkers and replacing them with community notes, he explained, similar to the way X has dealt with content moderation. The change will first take place in the US, said Zuckerberg – suggesting that other countries could soon follow suit.

Tech platforms have traditionally tried to enforce their content rules with a combination of automated and human review, with varying success. The issues with content moderation are multifarious, but include defining exactly what the rules should be, with the risk of annoying people of different political views, and managing the sheer scale of messages – Meta has more than 3 billion users across its family of apps, which include Facebook, Instagram and WhatsApp.

"There are some benefits to community notes, but they aren't a replacement for fact-checking"

Adopting crowdsourced community notes alongside content moderators – Meta had around 40,000 according to testimony in front of the US Congress in January 2024 – is a bold move. But early research into X's community notes indicates they may not be particularly effective.

A November 2024 study found that introducing community notes to X, then known as Twitter, in 2021 didn't reduce engagement with misinformation on the platform. The research suggests the way the system worked was too slow to stem the spread of false information across the platform.

However, other studies have indicated that community notes can stop harmful content spreading too quickly. In April 2024, another study analysed 285,000 notes appended to tweets, mostly from 2023, and found that the additional context can reduce the number of retweets of any post by half.

Social media researchers are already sounding a note of caution. "Meta's decision will only have negative consequences for the global public," says Steven Buckley at City St George's, University of London. "Whilst there are some benefits to having community notes, they do not serve as a replacement for actual fact-checking. They should be seen as an additional layer of protection against misinformation, not the only layer."

But with Meta getting rid of independent fact-checking organisations, it seems the wisdom of the crowd – or lack thereof – will prevail. "Community notes are rife with abuse, especially by those who want to push a particular political agenda," says Buckley.

The idea that X, which has haemorrhaged users under Elon Musk's ownership, is being held up as an example to follow also worries Buckley. "Over the past year, we have seen X devolve into a misinformation hellscape with its sole reliance on community notes," he says. "Meta's various platforms will now likely succumb to the same fate."

DAVID PAUL MORRIS/BLOOMBERG VIA GETTY IMAGES

Mark Zuckerberg, Meta's CEO, plans to move moderators to Texas

Rise of populism

That Zuckerberg's announcement comes less than two weeks before Donald Trump returns to the White House as US president has also raised eyebrows. "This year already feels like a tipping point for social media policy," says Philipp Lorenz-Spreen at the Max Planck Institute for Human Development in Berlin. "If we would have acted in 2016, it would have been much easier than it is now to regulate online platforms in a democratic way."

Lorenz-Spreen says this is part of a wider change by social media platforms to try to appease a broader shift in political views. The rise of populism has pushed conversations rightwards, with right-wing, populist parties seeing success in elections around the world. Once-fashionable diversity, equity and inclusion business practices are increasingly denigrated, with companies such as Walmart and McDonalds dropping their diversity pledges.

Zuckerberg nodded to this trend in his video, announcing plans to move some content moderation teams from California to Texas, in other words from a left-leaning state to a firmly Republican one. "The political climate has changed and the – mostly US-based – companies will adapt and change their policies in a direction that benefits Trump," says Lorenz-Spreen. ▮

3 billion
Number of Meta users, including on Facebook and Instagram

40,000
Number of content moderators working at Meta in 2024

50%
Reduction in retweets on X posts that have a community note

Archaeology

Silver mining in the Roman Empire would have reduced IQ

Christa Lesté-Lasserre

EXTENSIVE silver mining may have exposed ancient Romans to high levels of lead pollution in the air, probably leading to a general drop in their IQ.

Analyses of Arctic ice layers point to concentrations of atmospheric lead at the Roman Empire's height that were about three times what they are today in the US. The effect on the intelligence of ancient people across Europe – especially in major coin-making regions in Iberia – would have been significant, says Joseph McConnell at the Desert Research Institute in Reno, Nevada.

> "The idea that you had this heavy metal pandemic 2000 years ago is mind-boggling"

"The idea that you had this human-caused heavy metal pandemic 2000 years ago is kind of mind-boggling," he says.

Lead poisoning is known to cause cognitive deficits, as well as health problems like heart disease and reduced immunity.

Roman water pipes and pottery exposed citizens to lead contamination, which is reflected in previous analyses of the bones and teeth of mostly well-off, urban Romans. However, McConnell and his colleagues suspected that atmospheric lead pollution might have had a wider effect, including on the rural non-elite, whose remains are rare and less studied.

According to ancient texts, Romans smelted a lead-rich mineral called galena to obtain silver for coins. That would have released about 10,000 grams of lead for every gram of harvested silver, says McConnell.

While most of that lead hovered within the Roman Empire – and especially over metal-working areas – smaller quantities would have spread across Europe and ended up in the glaciers of Greenland within a matter of days.

Glacier ice tends to pack into easily distinguishable layers about 10 centimetres thick every year, so scientists can accurately date them and the chemicals they harbour. McConnell and his team revisited archived lead records from three glacier ice cores taken in Greenland and the Russian Arctic, which cover the years 500 BC to AD 600.

Adding in atmospheric modelling, the researchers determined that in areas closest to where smelting took place, lead concentrations probably exceeded 150 nanograms per cubic metre of air at the height of the Roman Empire, from 27 BC to AD 180. That translates into more than 500,000 tonnes of lead being released into the atmosphere during that time.

Air bubbles containing lead pollution became trapped in Greenland ice

JOSEPH MCCONNELL

Based on studies of modern lead exposure in children under age 5, the team estimates that young Roman children would have had an average blood concentration of about 3.5 micrograms per decilitre (*PNAS*, doi.org/g8xttk). In contrast, lead levels in the blood of children in the US were 0.8 micrograms per decilitre in 2016.

Based on epidemiological studies, the ancient levels of lead air pollution would have caused an average drop in IQ of 2.5 to 3 points across the entire Roman Empire – with much bigger effects in the smelting zones.

Beyond the empire, all of Europe – and probably even North America – would have been affected by the Romans' lead pollution, says McConnell. ▮

Zoology

Secrets of velvet ant's venom explain its painful sting

THE sting of a female velvet ant is one of the most painful in the animal kingdom. Now, researchers have discovered that these insects have multiple proteins in their venom that make it effective against a wide range of victims.

Velvet ants are in fact a family of wingless wasps with more than 7000 species. The researcher Justin Schmidt, who invented the Schmidt sting pain index, described their sting as "explosive and long-lasting, you sound insane as you scream. Hot oil from the deep fryer spilling over your entire hand."

To investigate what makes it so painful, Dan Tracey at Indiana University and his colleagues asked members of the public to carefully collect female scarlet velvet ants (*Dasymutilla occidentalis*) from sites in Indiana and Kentucky.

They tested the venom on fruit flies (*Drosophila melanogaster*), mice (*Mus musculus*) and a Chinese mantis (*Tenodera sinensis*), a potential predator of velvet ants.

One of the peptides that the team isolated from the venom, called Do6a, clearly caused a response in insects but, surprisingly, not in mice.

"This means that the venom has evolved to have components that are specifically targeting pain-sensing neurons of insects," says Tracey.

The team further tested this by allowing a praying mantis to attempt to capture velvet ants. "We discovered that the velvet ants always escaped from the grip of the mantis by stinging it in self-defence," says Tracey.

IVAN KUZMIN/ALAMY

A velvet ant's sting has been described as explosive and long-lasting

However, mice did show strong pain responses when tested with other peptides isolated from the velvet ant venom (*Current Biology*, doi.org/nz8w).

After finding the peptides that cause pain in different animals, the researchers compared the venom peptide sequences with those of four other velvet ant species.

"All of them have an almost identical version of the peptide that potently activates insect pain-sensing neurons," says Lydia Borjon, a team member at Indiana University. "So, it is likely that pain is caused in a similar way in other velvet ant species." ▮

James Woodford

Health

Sleeping pills disrupt the brain

A common sleep medication seems to slow down the brain's waste disposal system

Grace Wade

SLEEPING pills might help you doze off, but the sleep you get may not be as restorative. When mice were given zolpidem, a medication commonly found in sleeping pills such as Ambien, it prevented their brains from effectively clearing waste during sleep.

Sleep is critical for removing waste from the brain. At night, a clear liquid called cerebrospinal fluid circulates around brain tissues, flushing out toxins through a series of thin tubes known as the glymphatic system.

Think of it like a dishwasher that the brain turns on when asleep, says Maiken Nedergaard at the University of Rochester Medical Center in New York. However, the mechanism that pushes fluid through this network wasn't well understood – until now.

Nedergaard and her colleagues implanted optical fibres in the brains of seven mice. By illuminating chemical compounds in the brain, the fibres let them track the flow of blood and cerebrospinal fluid during sleep.

They found that as levels of a molecule called norepinephrine (also called noradrenaline) rise,

"Think of the brain's waste removal system like a dishwasher that it turns on when asleep"

blood vessels in the brain constrict, decreasing the volume of blood and letting cerebrospinal fluid rush into the brain. When norepinephrine levels fall, blood vessels expand, pushing cerebrospinal fluid back out.

In this way, fluctuations in norepinephrine during non-rapid eye movement (NREM) sleep stimulate blood vessels to act like a pump for the glymphatic system, says Nedergaard.

This finding reveals that norepinephrine plays a crucial role in cleaning waste out of the brain. Previous research has shown that, as we sleep, our brains release this chemical in a slow, oscillating pattern. These norepinephrine waves occur during NREM, which is a crucial sleep stage for memory, learning and other cognitive functions.

Next, the team treated six mice with zolpidem, a sleep medication commonly sold under the brand names Ambien and Zolpimist. While the mice fell asleep faster than those treated with a placebo, the flow of cerebrospinal fluid in their brains dropped by roughly 30 per cent, on average (*Cell*, doi.org/g8x4gd). In other words, "their brain doesn't get cleaned very well", says Nedergaard.

Although the experiment tested zolpidem, nearly all sleeping pills inhibit the production of norepinephrine. This suggests they may interfere with the brain's ability to flush out toxins.

It is too soon to tell whether these results will translate to humans. "Human sleep architecture is still fairly different than a mouse, but we do have the same brain circuit that was studied here," says Laura Lewis at the Massachusetts Institute of Technology. "Some of these fundamental mechanisms are likely to apply to us as well."

If sleeping pills do interfere with the brain's ability to remove toxins during sleep, that means we must develop new sleep medications, says Nedergaard. Otherwise, we risk exacerbating sleep problems, potentially worsening brain health in the process. ▮

Cooking

How to make perfect cacio e pepe pasta – according to science

PHYSICISTS have discovered the key to a consistently delicious cacio e pepe, a traditional Italian pasta dish made with black pepper and pecorino cheese: extra cornstarch.

Cooking cacio e pepe involves melting the cheese with some of the water the pasta is cooked in to create a smooth sauce, but achieving this is notoriously tricky. If the mixture becomes too hot or has the incorrect balance of cheese and starch from the pasta water, then the sauce will become lumpy.

Ivan Di Terlizzi at the Max Planck Institute for the Physics of Complex Systems in Germany and his colleagues tested how the consistency of cacio e pepe sauce changed in hundreds of different recipes.

Di Terlizzi, who is Italian but is now based in Germany, came up with the idea while cooking with his Italian colleagues. "Pride played a little bit of a role in this because we cook a lot outside of Italy, because we miss our food," he says. "I was cooking a lot, and 50 per cent of the time that I was preparing cacio e pepe, I [messed] it up, and this was so terrible for my pride – I couldn't understand why."

To test different ingredient combinations, Di Terlizzi and his colleagues first mixed different proportions of cheese, starch and water together using a blender, before heating it in a pan with a sous vide cooker, a kind of heated water bath. Once a target temperature had been reached, they extracted some of the sample in a Petri dish and photographed it.

MYVIEWPOINT/ALAMY

Black pepper, pecorino cheese and spaghetti are the basis of cacio e pepe

From these pictures, they could assemble what physicists call a phase diagram for cacio e pepe, which shows the different states the sauce can take under varying conditions, such as starch concentration or temperature. They found that one of the most important conditions for a smooth sauce is a starch level of 2 to 3 per cent (arXiv, doi.org/nz9j). Pasta water is typically only around 1 per cent, so Di Terlizzi and his team recommend adding cornstarch.

The findings won't come as a shock to food scientists, says Peter Fryer at the University of Birmingham, UK. "Rule one in these things is that experiment is always ahead of theory, or people would not have been making pasta sauces for the last 1000 years." ▮

Alex Wilkins

Technology

Batteries made from waste could store renewable energy

Matthew Sparkes

AN INDUSTRIAL waste product has been converted into a component for batteries that can stably store large amounts of charge. Such batteries could perform a vital function for power grids by smoothing out the peaks and troughs of renewable energy.

Redox flow batteries (RFBs) store energy as two liquids called an anolyte and a catholyte in a pair of tanks. When these fluids are pumped into a central chamber, separated by a thin membrane, they chemically react and produce electrons to generate energy. The process can be reversed to recharge the battery by placing a current across the membrane.

Such batteries are cheap, but they have downsides. They are bulky, often as big as a shipping container, and require constant maintenance due to the moving parts involved in pumping the liquid. They also rely on metals like lithium and cobalt, which are in short supply.

Now, Emily Mahoney at Northwestern University in Evanston, Illinois, and her colleagues have discovered a simple process that can turn a previously useless industrial waste product into a useful anolyte, which could potentially replace these metals.

Their process takes triphenylphosphine oxide, created in the manufacture of products including vitamin tablets, and turns it into cyclic triphenylphosphine oxide, which has a high potential for storing negative charge. When used as an anolyte, it shows no reduction in effectiveness even after 350 charging and draining cycles (*Journal of the American Chemical Society*, doi.org/nz9m).

RFBs could be used to store energy from wind and solar generation, says Mahoney, but they are unlikely to replace lithium-ion batteries in cars or smartphones because of their bulk. ▮

Palaeontology

Why sabre-toothed animals evolved their terrifying bite

Chris Simms

L: MAURICIO ANTON/SCIENCE PHOTO LIBRARY; R: STEVE MORTON

The sabre-toothed tiger *Smilodon* had extremely long teeth that were optimal for puncturing prey

PREDATORS have evolved sabre teeth many times during the history of life – and we now have a better idea why these fangs develop as they do.

Sabre teeth have very specific characteristics: they are very long, sharp canines that tend to be slightly flattened and curved. They have independently evolved in mammals at least five times, and fossils of sabre-tooth predators have been found in the Americas, Europe and Asia. They were last seen in *Smilodon*, often called sabre-toothed tigers, which existed until about 10,000 years ago.

To investigate why these teeth kept re-evolving, Tahlia Pollock at the University of Bristol, UK, and her colleagues looked at the canines of 95 carnivorous mammal species, including 25 sabre-toothed ones.

First, they measured the shapes of the teeth to categorise and model them. Then they 3D-printed smaller versions of each tooth in metal and carried out puncture tests, in which the teeth were pushed into gelatine blocks designed to mimic the density of animal tissue.

This showed that the sabre teeth were able to puncture the block using up to 50 per cent less force than the other teeth (*Current Biology*, doi.org/nz83).

"A carnivore's teeth have to be sharp and slender enough to allow the animal to pierce the flesh of their prey, but they also need to be blunt and robust enough to not break while an animal's biting," says Pollock.

Creatures like *Smilodon* had extremely long sabre teeth. "These teeth were probably popping up again and again because they represent an optimal design for puncture," says Pollock. "They're really good at puncturing, but that also means that they're a little bit fragile." For instance, some fossils of *Smilodon* found at the La Brea Tar Pits in California have broken teeth.

"A carnivore's teeth have to be sharp and slender to pierce flesh, but robust enough to not break"

Other sabre-toothed animals had teeth that were the ideal shape for a slightly different job. The cat *Dinofelis* had squatter sabre teeth that balanced puncturing and strength more equally, says Pollock.

Those of other sabre-toothed species sat between these optimal shapes, which might be why some of them didn't last too long. "These kinds of things trade off," says Pollock. "The aspects of shape that make a tooth good at one thing make it bad at the other."

One of the main hypotheses for why sabre-tooth species went extinct is that ecosystems were changing and the huge prey they are thought to have targeted, such as mammoths, were disappearing.

The team's findings back this up. Sabre teeth wouldn't have been as effective for catching prey that were more like the size of a rabbit, and the risk of tooth breakage may have increased, so sabre-toothed animals would have been outcompeted by other predators, says Pollock.

"As soon as the ecological or environmental conditions change, the highly specialised sabre-tooth predators were unable to adapt quickly enough and became extinct," says Stephan Lautenschlager at the University of Birmingham, UK. ▮

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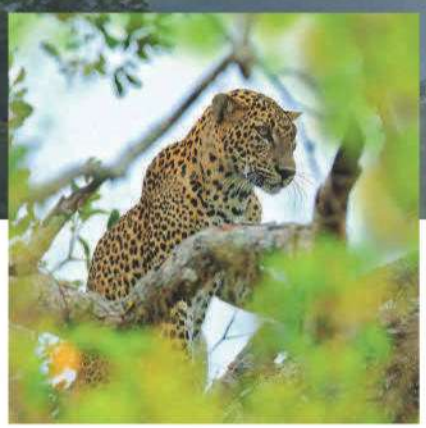

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Comment

An ancient killer

This month marks a year since the malaria vaccine rollout began. Here's what we still need in order to beat a disease as old as ancient Egypt, says **Azra Ghani**

MALARIA is one of humanity's oldest killers, with records of cases dating back to ancient Egypt. But despite efforts to eradicate the disease, a new report from the World Health Organization estimates that nearly 600,000 people died of malaria in 2023, most of whom were children.

Progress in reducing the number of deaths has stagnated, with malaria cases increasing since 2018 because of a perfect storm of challenges. Growing resistance to insecticides and drugs has made prevention and treatment methods less effective. The rise in extreme weather events like flooding, caused by climate change, has allowed for the proliferation of new habitats for malaria-carrying mosquitoes. And funding shortfalls to the global agencies that bankroll and deliver key interventions have made it harder to ensure such measures reach those who need them in sufficient quantities.

But despite these obstacles, we are continuing to innovate and make progress. This month marks one year since the rollout of the first malaria vaccine, RTS,S, which was followed by a second, R21, later in the year. R21 uses newer technology, making it cheaper to manufacture at scale, enabling faster deployment. These vaccines have now reached children in 17 countries, with more due later this year. Evidence from earlier pilot introductions of RTS,S in Ghana, Kenya and Malawi, where 2 million children have been vaccinated, has demonstrated a 22 per cent drop in malaria hospitalisations and a 13 per cent reduction in deaths from any cause for young children.

ELAINE KNOX

But vaccines alone aren't a silver bullet. As the malaria parasite continues to evolve, we need new innovations to defeat this ancient foe. This includes investment to future-proof core tools such as insecticides, replacing those that mosquitoes have evolved to resist, and new generations of life-saving treatments.

Promising new technologies are also in the pipeline, like gene drives, which genetically modify malaria-spreading mosquitoes by boosting inheritance of certain traits. Two options are on the table – amplifying genes that reduce the number of female *Anopheles gambiae* mosquitoes (those that spread malaria) or genes that prevent mosquitoes from passing on the parasite.

What makes gene drives particularly revolutionary is that, in theory, they would be self-sustaining. This is because the malaria-carrying mosquitoes themselves pass on these genes through the generations, limiting the need for repeat application by public health teams.

Other options include using a bacterial strain, *Delftia tsuruhatensis TC1*, which can be carried in the gut of mosquitoes and can block the development of the malaria-causing *Plasmodium* parasite, mirroring an approach tested to control dengue virus.

Viable future tools like these, alongside existing ones, could save an estimated 13.2 million lives in sub-Saharan Africa over the next 15 years, according to research in support of the Zero Malaria Experience, an awareness campaign. The work was done by my team at the MRC Centre for Global Infectious Disease Analysis at Imperial College London.

But scientists can't do this alone – funding is urgently needed for research and development, and for rolling out these interventions. This year represents a crossroads moment, with both Gavi and the Global Fund, vital international health organisations responsible for ensuring help reaches those who need it, awaiting funding commitments from governments around the world.

Only with this support in place can we develop the full toolbox of malaria interventions we need and ensure they are distributed effectively. But if we can do this, we will be a step closer to ending a killer as old as the pharoahs. ▮

Azra Ghani directs the MRC Centre for Global Infectious Disease Analysis in London

Future Chronicles

Into the spider-verse

By 2029, we had learned how to make synthetic spider silk, leading to a revolution in clothing and medicine, says our guide to the future **Rowan Hooper**

Rowan Hooper is *New Scientist*'s podcast editor and the author of *How to Spend a Trillion Dollars: The 10 global problems we can actually fix*. Follow him on Bluesky @rowhoop.bsky.social

In Future Chronicles, he explores an imagined history of inventions and developments yet to come.

This column appears monthly. Up next week: Chanda Prescod-Weinstein

ONE of the things children of the late 21st century remark on, when looking back at people in the 2020s, is the clothes. What are they wearing, the kids ask. The issue isn't so much the design and the peculiar fashion as the fabrics. Kids these days wear clothes made from silk – spider silk – from head to toe. They can't imagine wearing garments that scuff and fray, that are heavy, ugly and vulnerable to dirt and acid, that exert a high environmental price to produce and that wear out in a few years. Hell, in the olden days, clothes weren't even bulletproof.

Spider silk began to replace other natural fibres, such as cotton and wool, and artificial fabrics like fossil fuel-derived nylon and elastane in the 2020s. Among all natural and synthetic materials, spider silk is the toughest known fibre, stronger, weight for weight, than high-tensile steel and Kevlar. Its properties outcompete traditional silk (from the cocoon of the silk moth *Bombyx mori*), but the reason why it never caught on is that spiders are territorial and produce only small amounts of silk. Spider farms were never viable.

It wasn't that we learned to farm spiders – we instead figured out how to use microbes to make the silk. These were grown in giant vats and produced a mixture of silk proteins, known as silk dope.

One problem was creating all the complex ingredients that make up silk. Spider silk consists of very large proteins called spidroins, larger than bacteria are usually able to produce. Another problem was assembling the large proteins into a complex, ordered structure. Synthetic silk dope also typically required purification with harsh solvents before it was spun into fibre. Eventually, we learned how to make large spider silk proteins that were soluble in water.

Anna Rising at the Karolinska Institute in Sweden led a team that managed to produce high yields of soluble microbial spider silk in the early 2020s. By then, a Japanese-Thai collaboration, Spiber, was already producing silk dope in bioreactors up to 1000 cubic metres in size. Other companies at the forefront of research and development included Bolt Threads in the US, AMSilk in Germany and Inspidere in the Netherlands.

Microbial production of silk has a number of advantages over that of spiders. Unlike aggressive spiders, microbes can be grown at high density. Also unlike spiders, microbes will feed on pretty much anything. Bioreactor production lines were built that used specialised microbes to break down old textiles and clothes into glucose, which was then fed to the silk producers. Waste products from household, agricultural and industrial processes were broken down into glucose and glycerol, then fed into silk bioreactors.

"Spider silk clothing became common, leading to unheard-of levels of comfort, protection and sustainability"

As production scaled up, the sustainability benefits and economic savings led to spider silk replacing animal-derived fabrics, materials such as keratin, gelatine and elastin, and products like nylon. In the mid-2020s, the textile industry consumed over 60 million tonnes of plastic-based fibres per year, most of which ended up in landfill. The pivot to synthetic spider silk helped cut this to a manageable amount.

Synthetic silk can be easily augmented. In 2016, a synthetic spider silk was made with a novel amino acid, which was bound to an antibiotic. This created a silk with antimicrobial properties. Many kinds of silk were ultimately created for medical and surgical purposes, such as tissue scaffolds, bone repair and strengthening, organ replacement and even brain-computer interfaces.

Just as spiders produce several different types of silk (for high-strength scaffold lines, prey capture, egg wrapping and adhesion), different synthetic spider silks were produced with different properties. Fashion design underwent its biggest revolution since the advent of nylon. Once a luxury product, silk clothing became commonplace, leading to unheard-of levels of comfort, protection, warmth, sustainability and style. For those who needed it, bulletproof silk patches could be incorporated into clothing.

There was another spin-off from the spider revolution. The must-have toy in the mid-21st century was a Spider-Man-inspired web slinger. Bioengineers worked out how spiders turn the liquid silk dope in their storage glands into high-tensile fibres and spin these in air. When synthetic dope was forced through a narrow nozzle, it created a thin scaffold fibre, which, when combined in an array, created superstrong adhesive webs.

Originally designed for military use, a version of the web slinger became commercially available. The number of young people flinging themselves off tall buildings for fun hadn't been seen since the antics of Miles Morales and friends in the classic 2018 film *Spider-Man: Into the Spider-Verse*.

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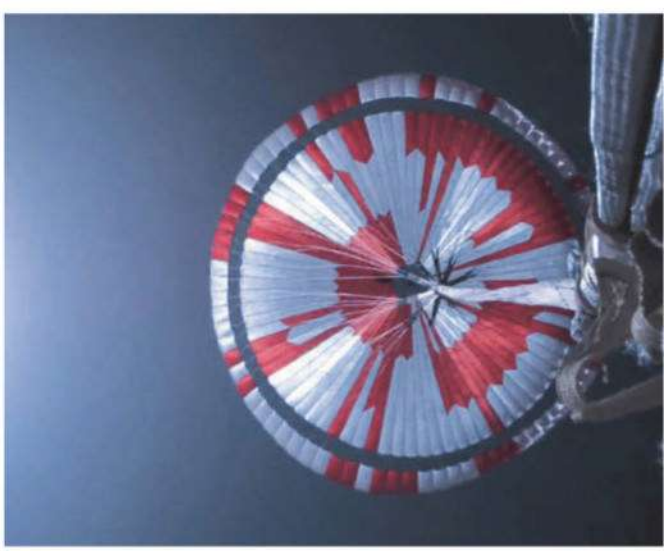
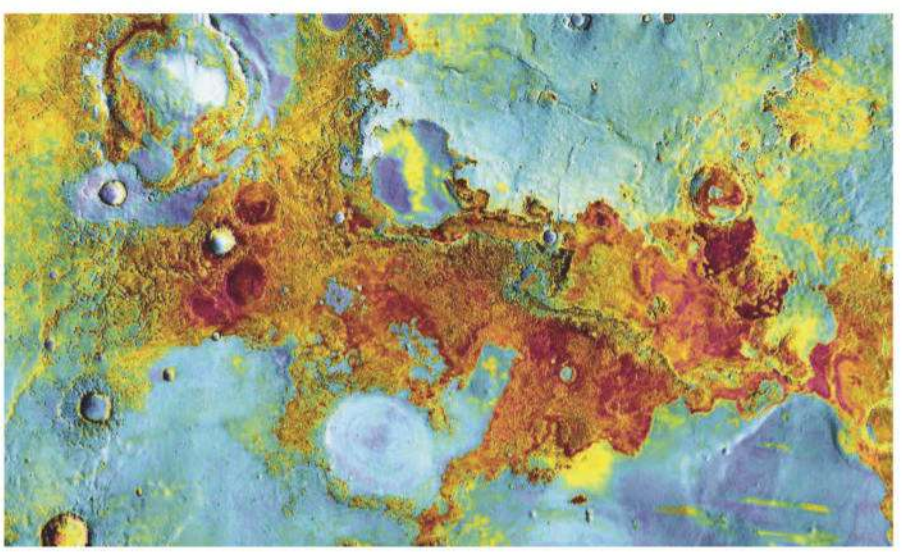


Setting foot on the Red Planet
Human exploration of Mars is coming, says NASA's former chief scientist **newscientist.com/video**



Seeing red

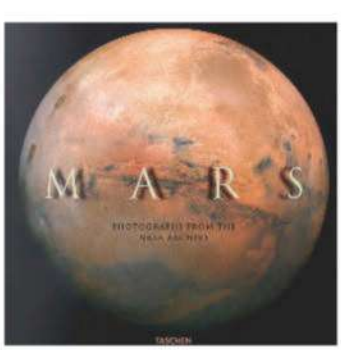
NASA/JPL-Caltech
TASCHEN

FROM H. G. Wells's alien invaders in *The War of the Worlds* to *The Martian*'s abandoned astronaut, we have long been inspired by the idea that life could reside on Mars – human or otherwise. Flybys, orbiters and landers, including NASA's Perseverance rover and its aerial sidekick, Ingenuity, have made Mars one of the best understood planets in our solar system. Now, more than ever, we are closer to answering the question: could life exist there?

A new book, *Mars: Photographs from the NASA archive*, celebrates the missions that have enriched our understanding of Mars and looks to a future where humans explore the Red Planet.

Clockwise from top, far left: the Dingo gap in Gale crater, which NASA's Curiosity rover crossed; an impact crater at Meridiani Planum, shot by the Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment camera; Mars's surface temperature, from cold blue to warm red, captured by the Mars Odyssey spacecraft's Thermal Emission Imaging System; Perseverance photographs the parachute used to slow its landing; a rocket-powered stage lowers Perseverance onto Mars in a "sky crane" manoeuvre.

David Stock



Editor's pick

Mixed views on the push to suck carbon from the air

28 December, p 11

From David Muir, Edinburgh, UK

It was good to read about the advances in direct air capture of carbon dioxide. However, the purchase of offset carbon credits by large corporations on the back of this strikes me as nothing more than a licence to pollute. Such firms should be doing more at source to cut emissions, but I reckon the cost of actually improving their environmental credentials is greater than the cost of the credits they buy (or they wouldn't be buying them). This is a public relations exercise to save money and to excuse dubious anti-pollution practices.

Even after it is greenwashed, these corporations' environmental and ethical laundry will still retain the scent of hypocrisy.

From Andrew Benton, Flourtown, Pennsylvania, US

Scaling up direct air capture (DAC) raises many questions. How will the giant new plant be powered? In other words, how much carbon dioxide will be released into the atmosphere to power this plant?

What's more, how long will such plants need to operate to remove the same amount of CO_2 that was released as a result of their manufacture and construction?

And if the money it takes to build DAC plants was put into solar panels and/or wind turbines, would the lifetime reduction in atmospheric CO_2 be similar, or maybe even better? Until I see some numbers, I am sceptical about the true value of DAC.

From Martin van Raay, Culemborg, Netherlands

Considering that the world's terrestrial vegetation absorbs some 12 gigatonnes of carbon dioxide every year, wouldn't it have been better to not invest in this plant, but to grow more trees instead? Also, let's stop burning existing trees – allow them to live a full life, then turn them into useful products, so this CO_2 is stored for tens or even hundreds of years. Why build industrial plants to do what real plants already do better?

Concern over welfare of AI chatbots is misplaced

28 December 2024, p 12 and p 17

From Zoë Jewell, Durham, North Carolina, US

I was struck by the juxtaposition of the article on the use of CRISPR technology to create disease-resistant pigs and another piece urging us to consider the welfare of AI chatbots. This highlights a troubling inconsistency in our ethical priorities. On the one hand, we are developing tools to intensify pig production, perpetuating a system where intelligent, emotionally complex beings exist in a living hell. On the other, we debate the rights and welfare of chatbots – entities that currently lack even simple consciousness.

If we can consider the welfare of artificial entities, surely we can do so for sentient, suffering animals.

From John Kitchen, Kettering, Northamptonshire, UK

No one has yet proven that artificial intelligence in its true sense even exists. In fact, there are many reasons to say that it doesn't, including the fact that no "AI" has yet demonstrated critical reasoning. Starting to talk about the rights or welfare of AI is therefore utterly ridiculous.

Shower far less? Try a bath once a fortnight

28 December 2024, p 28

From Emily Wolfe, Bristol, UK

In your ultimate guide to skincare, David Robson says that showering a few times a week may suffice to keep the body's outer layer in good condition. Speaking as an older reader who didn't encounter a shower in someone's home until the age of 18, I can assure him that showering zero times a week suffices. Consider how much energy, water and money could be saved by a return to the old regime of a quick wash once a day or when necessary and having a bath once a week or fortnight. Perhaps this should be recommended to the eco-conscious.

Not all weight loss is a good thing

11 January, p 19

From Penny Jackson, Barrow-in-Furness, Cumbria, UK

If weight loss were to occur as a side effect of using semaglutide to treat heart disease, that might not always be a good thing. I am talking about for treating older people, who may be severely underweight already. Weight loss wouldn't be healthy there.

Two takes on talk of society's breakdown

14/21 December 2024, p 52

From Wai Wong, Melbourne, Australia

Cities like Singapore, Tokyo and Hong Kong enjoy relatively low crime rates and long lifespans despite population densities 100 times the planet's average – hardly evidence of a John Calhoun-style breakdown due to population growth. There are problems due to overpopulation, but not of the sort he predicted.

From Murray Upton, Canberra, Australia

It is wrong to claim that Calhoun's forecast of social breakdown in an increasingly crowded world "hasn't (for the most part) materialised". It seems to me that Earth's population is indeed in the middle of its "behavioural sink" and unfortunately appears likely to destroy itself.

Many reasons to say no to a Mars colony

Letters, 28 December

From Brad Elliott, Sydney, Australia

A lunar colony would be far preferable to one on Mars. Its foundation is within the ambit of modern technology, and it could be rapidly serviced from Earth. The moon has many valuable resources, including water, which could be used alongside excellent solar power generation, unaffected by dust storms as it would be on Mars. There is no need to go to Mars to create an extraterrestrial colony.

From Martin Welbank, Cambridge, UK

Keeping a Mars colony going as a useful backup for humanity would be astronomically expensive, and you would need to continue this for thousands of years, just on the off-chance of something truly awful happening on Earth. It is a childish distraction from the less glamorous but more important problem of adapting to live on this planet sustainably, which, if done, would address most disaster scenarios, bar an asteroid strike.

Philosophers don't always get facts right

Letters, 7 December

From Gabriel Carlyle, St Leonards-on-Sea, East Sussex, UK

We are urged to try the writing of philosophers, such as the "impeccable logic" of Bertrand Russell, as a remedy for poor fact-checking in popular science books. Turning to Russell's 1948 book *Human Knowledge: Its scope and limits*, we read that "helium... has a nucleus consisting of four protons and two electrons". ▮

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Madeleine Cuff
Environment reporter

Myths and mental illness

Rebutting the serotonin theory of depression exposed an important gap in our knowledge. But is it the whole story, asks **David Robson**

Book
Chemically Imbalanced
Joanna Moncrieff
Flint Books

JOANNA MONCRIEFF was a "precocious 14-year-old" when she experienced "a period of what might have been called depression". She didn't seek treatment, however. "I didn't want to take anything that would stop me reading my philosophy books." Luckily, she changed schools, met "a lovely boyfriend" and was happy again. "I expect my resistance was coloured by my parents' general stoicism," she writes in her new book, *Chemically Imbalanced: The making and unmaking of the serotonin myth*.

Moncrieff cautions that "none of us can speak for anyone else about the nature of our feelings", yet, for me, her wording does imply that others simply lack the necessary stoicism to weather feelings of hopelessness and despair. We have been misled, she says, by the idea depression is a "direct result of a biological process" rather than "the expression of one's character".

We urgently need new ways to understand and treat depression

Moncrieff, a professor of critical and social psychiatry at University College London, attracted widespread attention in 2022 as co-author of a paper reviewing evidence for the "serotonin theory" of depression. This posits that depression is caused by low levels of serotonin, a key neurotransmitter that helps transmit signals between brain cells and may help regulate mood. In the paper, she concluded there was "no convincing evidence" for the idea. In her book, she is blunter, writing that "this narrative is a myth".

There is no denying the research's importance. Doubts about the serotonin theory had been growing, but Moncrieff's analysis provided the most comprehensive rebuttal to date – and rightly received considerable coverage for exposing this gap in understanding mental illness.

The big question, for many, concerned the implications for the largest class of antidepressants, selective serotonin reuptake inhibitors, or SSRIs, which had been thought to work by raising levels of the neurotransmitter within the brain's synapses.

Here, however, things get messy. Moncrieff's review didn't assess the effectiveness of these drugs, but other researchers have found that they do significantly reduce symptoms. So, even though we don't know why they work, many psychiatrists believe that SSRIs remain a valid treatment.

"Joanna Moncrieff says we have been misled by the idea depression is a direct result of a biological process"

It may be that SSRIs decrease inflammation, which has been linked to depression. They may also encourage neurogenesis (the growth of new brain cells) and neuroplasticity, thought to be impaired in some mental illness.

One person's depression might have different causes to another's. This raises possibilities of new, personalised treatments that target the specific pathways – as neuroscientist Camilla Nord compellingly described in her book, *The Balanced Brain*. But Moncrieff dismisses such research with far less rigour than in her analysis of the serotonin theory.

Many doctors and scientists believe that biological factors may predispose some to depression, and influence the progression of the disease. But Moncrieff writes that it "sounds nice to have a half-way house, where personal and biological factors mingle equally, but when biological processes are genuinely causal, they override human inclinations". Yet mingling is where much expert opinion lies.

Moncrieff concludes that we should see depression as a "meaningful human reaction" to life problems. This may be true in some cases. But even if we dismiss any neurological explanation of depression, much psychological research shows that depression is often accompanied by serious cognitive distortions – such as catastrophising – that warp our view of reality and exacerbate and prolong our symptoms. I worry some readers will see Moncrieff's message as saying their depressive symptoms are an accurate reflection of themselves and the world rather than a condition that can be treated.

But she is right to say that "When you are offered a solution to a complex problem in life that sounds too good to be true, it probably is." Depression is undoubtedly complex, and we desperately need new ways to understand and treat it. ▮

FOTOGRAFIABASICA/GETTY IMAGES

David Robson is an award-winning science writer and author of *The Laws of Connection: 13 social strategies that will transform your life*

Time for an imaginarium

An excellent guide to the power and complexity of our imaginations literally needs more space, finds **Peter Hoskin**

Book

The Shape of Things Unseen
Adam Zeman
Bloomsbury Circus

MAARTEN WOUTERS/GETTY IMAGES

What do you see above? Our imaginative minds can conjure up myriad possibilities

JUST imagine! No, seriously, just imagine: an apple, perhaps, or a cartful of apples, or even a kingdom in which monstrous apples are fought by oranges on horseback. Our imaginations are capable of this – and much more. They are responsible for films, novels and paintings, as well as buildings, computers and governments. They are unfathomably powerful.

And yet the imaginings themselves are gossamer – hard to hold onto, hard to pin down. I might be able to describe the apple I am thinking of, but what about the feeling I can conjure up of a loved one's presence? Or the acute memory of an apparently uneventful walk? It is literally all in my head, which makes it difficult to put into yours.

Enter Adam Zeman, a neurologist whose latest book, *The Shape of Things Unseen: A new science of imagination*, is a fine guide to the tricky science of the imagination. And tricky it is. Zeman begins by saying that he wants to make this "accessible", and he certainly pulls that off, but he has to do a lot of complexifying in the process.

After all, while we might think of imagination as mostly a visual feat – a sort of "seeing" by "the mind's eye" – there are instances where we smell something through "the mind's nose". Then there are people like Ed Catmull, co-founder of the Pixar animation studio, with no visual imagination at all – a mental characteristic Zeman has studied and named "aphantasia". Nothing is straightforward here.

So Zeman takes us on a necessarily meandering path; explaining, complicating, explaining again and, delightfully, trampling over various fences along the way. For a subject like the imagination, a certain breadth is to be expected, but his book is admirably wide-ranging. Zeman interviews the novelist Philip Pullman and the astrophysicist Martin Rees. He describes paintings and the functioning of synapses. This is a book that concerns art almost as much as it concerns science.

Though how could it not? As Zeman says, in one of his best aphorisms: "Science uses imagination to show us, so far as possible, how things really are; art, just as importantly, to show us how they feel." Both are highly imaginative acts.

If there is one thread running through *The Shape of Things Unseen*, it is the notion that "the 'real world' is almost as much a product of our creative minds as its countless virtual cousins". This idea of a "predictive brain" that generates and updates mental models to anticipate the world around it won't be news to anyone who read two of the best science books of 2023, Andy Clark's *The Experience Machine* and Camilla Nord's *The Balanced Brain*. But Zeman isn't claiming novelty: his book can be read as a follow-on in one of the most exciting experimental areas in neuroscience.

There is too much else to mention, which, in a way, is the major flaw here. For every cut-out-and-keep explanation of how neural networks operate, there is a brief history of the greenhouse effect that is less inexplicably concise than it is inexplicably there. For every case study of a man who convinced himself he was brain-dead, there are short Wikipedia-ish passages on Niccolò Machiavelli, Bernie Madoff and how Mary Shelley came to conceive of *Frankenstein* during a summer holiday in… yawn.

Even the interviews with Pullman and Rees feel rushed. I would have preferred Zeman to expand on his thinking across two or three volumes, to create an entire imaginarium, in fact. Which is both a criticism and a compliment – if you can imagine such a thing. ▮

Peter Hoskin is books and culture editor at *Prospect* magazine

New Scientist *recommends*

David Stock
Head of editorial video
London, UK

Last month, I saw Philippe Parreno's new work, ***Voices***, which is at the Haus der Kunst gallery in Munich, Germany, until 25 May. The artist wants us to create a journey through rooms of light sculptures, heat lamps, speaker arrays, dancers and film screens, guided by a disembodied, AI-generated voice.

A film, *El Almendral*, forms the centrepiece: footage from a tiny plot in southern Spain is live-streamed into the gallery and sensors feed raw data to an algorithm to activate and change exhibits. It is a heady mix that raises questions about personhood, climate change and cultural iconography in a fresh and enjoyable way.

Back in London, I am reading ***South Bank: Architecture & design*** (pictured) by writer Dominic Bradbury and photographer Rachael Smith. This celebrates

the brutalist Southbank Centre – designed for the UK's Festival of Britain in 1951 – which grew to include venues such as the National Theatre. It is well worth a read to dig into the UK's cultural past.

The sci-fi column

Reconsider Phlebas?

At his best, Iain M. Banks could be extraordinarily stylish, inventive and downright funny. So how does his genre-redefining science fiction stand up to the test of time? Emily H. Wilson finds out

Emily H. Wilson is a former editor of *New Scientist* and the author of the *Sumerians* trilogy, set in ancient Mesopotamia. The second book in the series, *Gilgamesh*, is out now. You can find her at emilyhwilson.com, or follow her on X @emilyhwilson and Instagram @emilyhwilson1

Books

The Culture series
Iain M. Banks
Orbit Books

Emily also recommends...

Book

The Wasp Factory
Iain Banks
Little, Brown
Nasty, original and very brilliant, this was Banks's debut novel, albeit not sci-fi. He really was a phenomenal talent.

JOSEPH BRANSTON/SFX MAGAZINE/FUTURE VIA GETTY IMAGES

Iain M. Banks wrote a succession of best-selling science fiction stories

IAIN M. BANKS died more than 11 years ago, but remains a titan of modern science fiction. He wrote "literary" works under the name Iain Banks, but added the "M" for his 14 sci-fi offerings, which are known for an audacious, ground-breaking take on the space opera that transformed the genre.

If you have never read any of these books but love "hard" sci-fi, is it worth diving in now?

Short answer: yes. Longer answer: Banks's sci-fi, at its best, is staggeringly inventive, beautifully written, dramatic and often very funny. His stories are packed with ideas, warships with minds very much of their own, alien races, charismatic drones and intergalactic politics.

That said, time is a stern judge. I have read celebrated "classics" of sci-fi and found them startlingly misogynistic, homophobic and racist – even for their time. There is nothing so serious to worry about here, but Banks's novels haven't aged perfectly. I reread five for this column, and even as a dyed-in-the-wool fan, I couldn't avoid the fact that, for books set in a future where men and women are meant to be equal, they don't always read that way.

Take *Excession*, where there are jokes about an alien race for which rape is part of everyday life. This is dealt with in a "jolly" manner, with the novel's hero worshipping the aliens and wanting to do everything they do. It is stuff that wouldn't get through an edit these days, I guess.

> **"Iain Banks added the 'M' to his name to write sci-fi. His take on space opera transformed the genre"**

You will make up your own mind about whether to proceed. If you do, I would start with his 10-book "Culture" series. These don't need to be read in order, though I suggest starting with *The Player of Games*, which is exciting and does a good job of setting out the universe these stories occupy.

Although there isn't a lot of spaceship action, you get the idea that superintelligent, sentient ships (aka, "the Minds") make the big decisions, but are benevolent towards humans. The Culture is a "post-scarcity" civilisation, so no one has to work. This can be dull, so Gurgeh, our hero and probably the best (human) player of games in the Culture, volunteers for Contact, an enterprise that deals with non-Culture civilisations.

Other fans argue for starting with the first published novel in the series, *Consider Phlebas*. The humans in the Culture are often quite alien, and Horza, this novel's protagonist, is a good example. He is a Changer who can transform into a copy of another human.

As to which Culture book is best, there is no consensus. Earlier reservations aside, I choose *Excession*. It has multiple points of view and plot strands. We also have spaceships and drones, action from the Special Circumstances unit (an offshoot of Contact), plus fascinating conversations between gangs of ships. Not to mention Culture warships firing on each other and a threat to the central society of the series from an "outside context problem", in other words, a far superior civilisation. So much going on and all brilliantly handled. Wow.

I have slight reservations about two of his sci-fi works. *The State of the Art* is really a novella, for fans only I would say, although it gives us the only peek at the Culture interacting with Earth. Then in *Feersum Endjinn*, a non-Culture work, part is written phonetically, which I limped through when I first read it. But in today's audio form that may not matter much.

Anyway, a very happy Iain M. Banks experience to you, should you choose to dive in. ▮

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Have we broken the jet stream?

If climate change is distorting the air currents that carry weather systems, we could be in for extreme weather that lasts longer and hits harder, finds **Madeleine Cuff**

AT THE end of October 2024, a grey gloom descended over the British Isles. Nothing unusual there. But this murky shroud was particularly persistent, even for the UK. Some regions barely saw the sun for a fortnight. Residents of the village of Odiham in Hampshire, for example, enjoyed just 12 minutes of sunshine in the first 11 days of November. And according to the Met Office, the UK's weather service, the country as a whole saw just 8.3 hours of sunshine across that period, well below average for that time of year. Meanwhile, in Spain, a slow-moving storm over the Valencia region unleashed torrential downpours, causing flash floods that killed 231 people.

For both events, you can blame the jet stream – the fast-moving air currents that flow west to east around the globe. In October 2024, the polar jet had buckled, trapping a high-pressure anticyclone system over the UK and a low-pressure system over Spain. That isn't unprecedented: the jet stream buckles from time to time. But even the casual observer might have noticed that weather events seem to be lingering longer across the northern hemisphere, from Europe to North America. Now, climate scientists are scrambling to figure out whether global warming is making the jet stream more erratic, as some have predicted.

We urgently need answers. If we don't get a clear picture of how the jet stream is changing, and what that means for our weather, we could be dramatically underestimating the extreme events coming our way. "We really need to keep pushing for an understanding of these extremes," says Tiffany Shaw at the University of Chicago.

While we tend to talk of the jet stream, singular, there are in fact four main jets circling the globe – two in the northern hemisphere and two in the southern hemisphere. Those nearest the poles are known as the polar jets, steered by the boundaries between temperate air and cold polar air. A second pair, called the subtropical jets, runs each side of the equator, sandwiched between the temperate air of the mid-latitudes and the warmth of the tropics.

Atmospheric blocks

The jets push weather systems along west to east, typically ensuring that we experience a change in outlook every few days. But they often meander, dipping and rising in altitude and latitude. Sometimes, especially if the winds weaken, the jets wander more extravagantly, looping back on themselves with the result that weather systems move more slowly than usual, or even get trapped in one location for an extended period.

Meteorologists call this an atmospheric block. "Blocking happens when those meanders get really large, the whole jet overturns and turns back on itself," says Tim Woollings at the University of Oxford, author of *Jet Stream: A journey through our changing climate*. Atmospheric blocks come in different forms. One of the most common is called an omega block, where the jet stream forms a large loop similar in shape to the Greek letter omega, with a high-pressure system squeezed between two low-pressure systems. There is also a dipole block, where the jet stream splits, trapping a high-pressure system towards the pole and a low-pressure system towards the equator.

GARY NEILL

Sometimes stretching over 3000 kilometres, blocks can consign those living under them to days, even weeks, of persistent weather – the nature of which depends on the time of year. "The impact will be really different in different seasons... if you are under the block in winter, that makes you colder, and in summer it makes you hotter," says Woollings.

The anticyclonic gloom that lingered over the UK in October and November, and the days of heavy rain in Spain, were the result of one such block. As were several other recent extreme weather events, including the Siberian heatwave of 2020 and the intense heat that engulfed parts of western North America in June 2021. "We're watching the real world unfold and deliver these unprecedented extreme events... all associated with very unusual jet stream patterns," says Jennifer Francis at Woodwell Climate Research Center in Falmouth, Massachusetts.

The problem for climate scientists, when it comes to figuring out how the jet stream is shifting in response to climate change, is twofold. Firstly, there is and always has been natural variation in the jet stream, from year to year and decade to decade – and indeed across regions. That makes it difficult to identify long-term trends. More importantly, however, we still don't fully understand how and why atmospheric blocks develop. "This is somewhat embarrassing," says Lei Wang at Purdue University in West Lafayette, Indiana. "No one really knows what the fundamental mechanism for blocking is."

There is no shortage of ideas. Some suggest that changes in north-to-south undulations in the atmosphere, known as Rossby waves, ›

sometimes pile into each other, causing a block to develop in the jet streams. Others see jet streams as "highways" for weather systems. They suggest that changes to the speed of the winds, prompted by topography or atmospheric shifts, can cause "traffic jams" on this highway. "The more crowded the weather systems, the slower the jet stream," says Noboru Nakamura at the University of Chicago, who pioneered the hypothesis. "That creates a logjam of traffic… this is just like traffic congestion on a highway."

If researchers don't fully understand what causes blocking, climate models can't account for it. Most of these project a general decrease in blocking events as the world warms, and therefore a decrease in persistent weather extremes. "If you look into the climate change predictions in the next 100 years, winter blocks especially are projected to be reduced," says Wang. In this scenario, jet streams will shift polewards in response to rapidly warming air in the tropics. As they do, the idea goes, the winds will strengthen, resulting in fewer slow-moving or blocked weather systems.

But not everyone buys that. Some researchers suggest, for example, that the northern hemisphere polar jet will weaken and become wavier as the Arctic warms. That is because a warmer Arctic reduces the temperature gradient between polar air and temperate air, slowing the winds and making the jet more likely to buckle, pushing cold air masses much further south than normal.

The trouble is that evidence to support either idea is thin on the ground because satellite observations only began in 1980. This is compounded by the fact that winter in the northern hemisphere presents a noisier picture anyway, largely due to the stratospheric polar vortex over the North Pole, which influences how the jet stream behaves and ensures there is much more natural variability.

For the northern hemisphere summer, however, a clearer picture is starting to emerge. The polar and subtropical jets are naturally weaker at this time of year because the temperature gradient between low and high latitudes is smaller. But there is now evidence to suggest the summer jets are weakening further because the high latitudes are warming faster than elsewhere, reducing the temperature gradient even more.

"In summer there is growing evidence, with observation and climate models agreeing, that climate change is leading to a weakening of the summertime circulation," says Kai Kornhuber at the International Institute for Applied Systems Analysis in Laxenburg, Austria. A weaker jet means weirder weather, he warns: "A weakening of the jet, or a slower jet, would lead to slower moving weather patterns and more persistent weather patterns."

"Heatwave hotspots" are already emerging across Europe, where heatwave temperatures are outpacing the extremes predicted by climate models, according to work from Samuel Bartusek at Columbia University in New York. These new extremes could be down to changes in blocking, he says. "One of the biggest influences on allowing these extreme heatwaves to happen is having a high-pressure system stuck in the same place for many days."

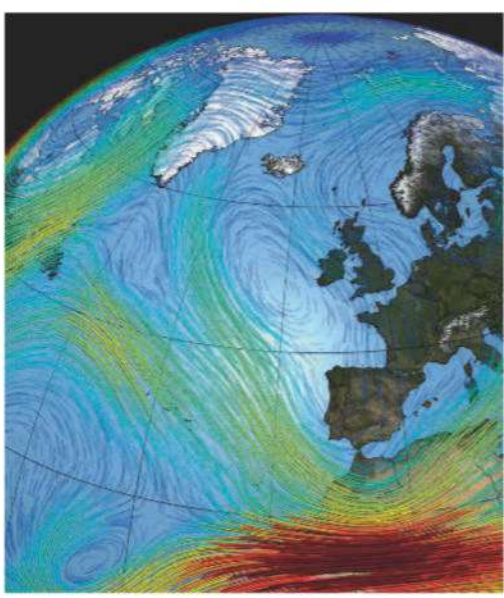
As well as identifying the extremes, researchers are also starting to explicitly connect these shifting weather patterns with jet stream changes. Working with Dim Coumou at the University of Amsterdam in the Netherlands and others, Kornhuber published a paper in 2022 that showed a rise in the frequency and intensity of heatwaves in Europe over the past 40 years and also connected it to an increase in the frequency and persistence of dipole blocks. These split jet formations, also known as double jets, push storms blowing through from the Atlantic northwards, leaving western Europe under persistent heat. In 2003, for instance, a double jet configuration lingered for 29 days over Europe during July and August, causing a prolonged, record-breaking heatwave that killed an estimated 70,000 people. According to Kornhuber and Coumou, these double jets have increased in frequency at a rate of around three days per decade and increased in persistence at a rate of around two days per decade since 1980.

Climate change link

That study didn't link these changes in the jet stream explicitly to climate change, but a paper published last year by Coumou and Rei Chemke at the Weizmann Institute of Science in Rehovot, Israel, made the crucial connection. That study demonstrated that human-induced climate change was the main driver behind a significant weakening in jet wind speeds between 1979 and 2020 during the northern hemisphere summer. It is one of the first pieces of research to demonstrate human-caused climate change is responsible for an increasingly erratic jet stream.

The upshot is that for the northern hemisphere summer at least, it looks like warming temperatures are causing the jet stream to weaken, leading to more persistent weather. The question then is, what can we

JOE RAEDLE/GETTY IMAGES


NASA'S SCIENTIFIC VISUALIZATION STUDIO

AFP VIA GETTY IMAGES

PATRICK T. FALLON/AFP VIA GETTY IMAGES

Stuck jet streams are contributing to extreme weather. Clockwise from top: Hurricane Helene in Florida; a heatwave in California; flash floods in Volos, Greece; and flooding in Derna, Libya. Left: the jet stream over Europe

NICOLAS HATZIPOLITIS/EPA-EFE/SHUTTERSTOCK

expect to happen in the future as the world continues to warm?

As those recent studies suggest, prolonged heatwaves look almost certain – particularly in Europe, which is known as a hotspot for atmospheric blocks. Days on end of sunshine might sound wonderful, especially to those who often labour under weeks of grey gloom. But prolonged heatwaves are dangerous, even deadly. The 2021 heatwave that hit parts of Canada and the US is testament to that. Hundreds died and infrastructure buckled: highways were closed, train power lines melted and crops withered in fields. On 30 June of that year, the village of Lytton in British Columbia was destroyed by a wildfire, killing two people.

Prolonged heat is also profoundly dangerous for the human body, especially when there is no opportunity for people to cool down during the night. Longer-lasting heatwaves significantly increase the risk of death from cardiac arrest and stroke. The risk is highest in regions where persistent hot weather is unusual, as homes will rarely have air conditioning.

Long spells of extreme heat are damaging to wildlife too, particularly when high temperatures strike temperate climates. In the UK, 40°C (104°F) temperatures in the summer of 2022 led to birds falling out of the sky. And while most plants and animals can cope with a day or two of high temperatures, prolonged exposure is often fatal to crucial species such as bumblebees, ecologists warn.

But lengthy heatwaves aren't the only danger posed by an increasingly wavy jet. Wet, stormy weather can be just as deadly, as the recent flooding in Spain demonstrates. Mid-latitude nations such as the UK are no strangers to wet weather, even in the summer. But such weather fronts usually blow through quickly. "If you are living in a city such as London, [intense rain] comes from the west, sweeps across the city and in a matter of 30 minutes it goes away," says Abdullah Kahraman at Newcastle University, UK.

As the polar jet weakens and waves during summer months in response to climate change, however, slow-moving rainstorms could become more frequent. Moving at around 3 metres per second, versus the 20 to 30 metres per second of a standard rainstorm, their sluggishness means huge amounts of rain can fall on just one location, overwhelming communities. In July 2021, Germany and Belgium were hit by a series of these slow-moving thunderstorms, resulting in flash floods that destroyed towns and killed at least 200 people.

Kahraman's analysis suggests slow-moving storms could become 14 times more frequent across land by the end of the century, under a high-emissions scenario. Summer and autumn are the most dangerous periods, with warm sea temperatures providing fuel for intense rainstorms. But the risk posed by this kind of extreme weather is a "mostly unexplored" issue in climate science, he warns.

The danger of slow-moving storms isn't just limited to Europe. Across the northern hemisphere, the probability of extreme rain falling for at least seven consecutive days will increase by 26 per cent for the mid-latitudes, according to a 2019 study, if global temperatures rise by 2°C above pre-industrial levels. There is also evidence indicating tropical cyclones are slowing across the western North Pacific, the North Atlantic and Australia as jet stream winds weaken.

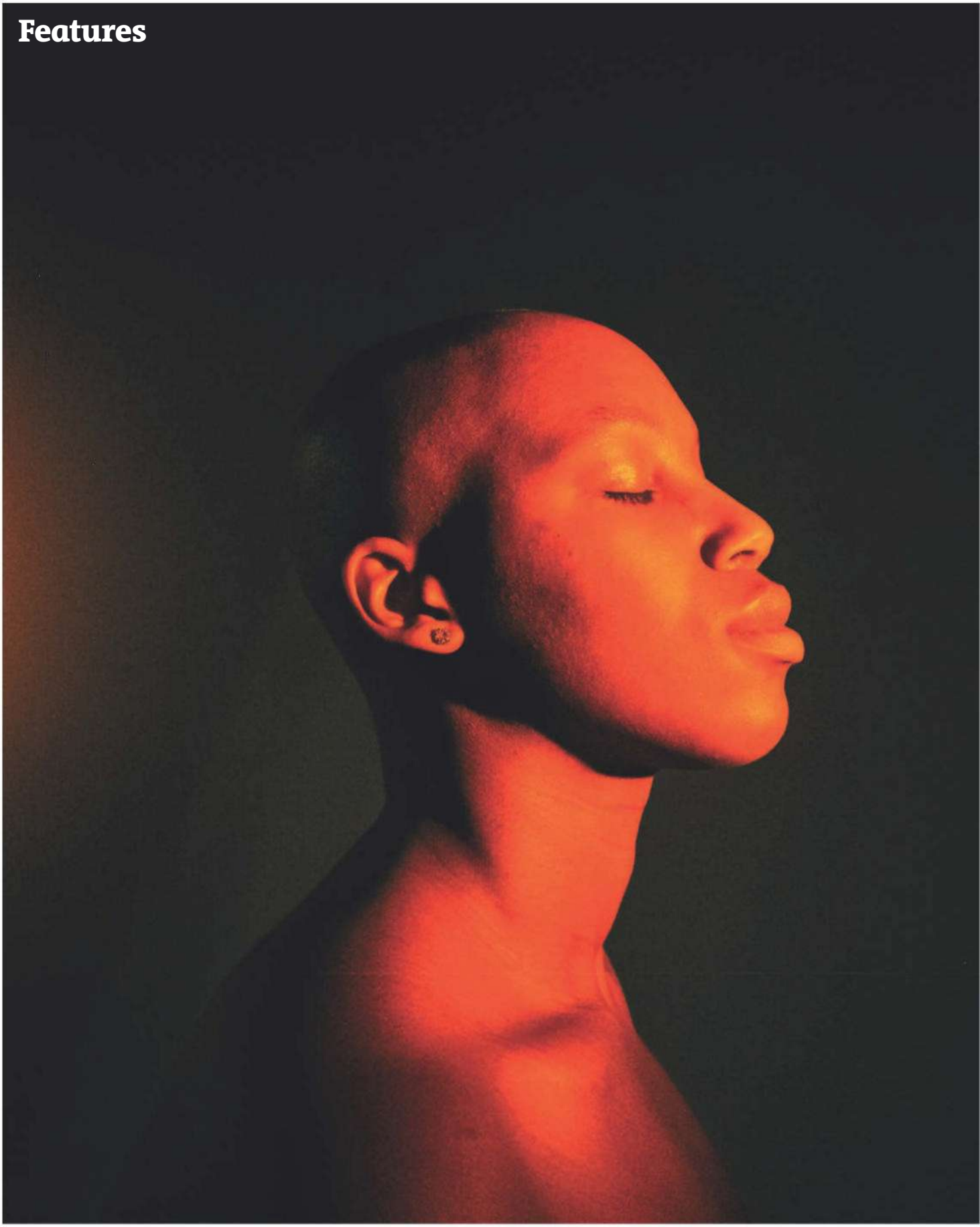
Wildfires and flash floods

The issue isn't just that slow-moving or stuck weather patterns may become more frequent. As the world warms, they will also become more noticeable. Climate change means heatwaves caused by blocked high-pressure systems are already more intense, increasing the risk of wildfires, droughts and ecological breakdown. Meanwhile, warmer air holds more moisture, meaning slow-moving storms can hold more rain, further increasing the threat of flash flooding. "We care about how hot the heatwaves are in the summer, we care about how much rain you get around the edge of a block," says Woollings. "Those impacts are going to get worse."

How much worse is the big, urgent question. Currently, climate models may not be accurately reproducing the changes to atmospheric processes wrought by climate change, says Kornhuber. "That then bears the risk of an underestimation of future extremes."

As the past few years have shown, we are far from ready for prolonged heatwaves or days and days of intense rain. Without a more accurate understanding of how jet streams are warping in response to climate change, hundreds of thousands of people will be left vulnerable. "We need to help people get ready for these unprecedented events," says Francis. "I think that's the most important thing." ▮

Madeleine Cuff is an environment reporter at *New Scientist*



JAKE WANGNER/STILLS

Wearables for the mind

A new wave of monitoring devices claim to improve our mental health, but do they work? **Helen Thomson** investigates

"YOU'VE achieved 40 seconds of uninterrupted focus."

Apparently, this is cause for celebration. For the past 10 minutes, I have been staring at my phone, trying to move a digital ball up a hill using nothing but the power of my mind. The Mendi headset I am wearing is analysing my brain activity and reflecting that back into the game. The more I concentrate, the higher the ball climbs.

This exercise is supposedly working out my mental muscle, just as one might use weights to train physical muscle, ultimately improving my focus and reducing my stress.

Like thousands of others, I have spent years wearing a smartwatch that helps me track my fitness and improve my physical health. But the wearables industry has its sights set on a new target: our mental health. We now have smartwatches and brainwave-reading devices that not only analyse the state of our nervous system, but actively intervene to supposedly improve our well-being, making mental health support more accessible – and wearable – than ever before. "We are leveraging the brain's ability to rewire itself so that you can increase your emotional control," says Mustafa Hamada, Mendi's chief product and science officer.

As someone who suffers from stress and anxiety, I am eager to try anything that will help me control it. But with my background in neuroscience, I am cautious of believing the hype. So I delved into the growing range of devices that target concentration, focus, stress and anxiety to figure out how they might work and which might really make a difference to my well-being.

The first wearable I was eager to use was the Muse headband, as I trialled an early prototype more than a decade ago. There are two devices to choose from – the Muse 2, a hard headband aimed at reducing stress and improving mood, and the Muse S, which uses soft sensors that can be comfortably worn at night to also track sleep. Muse is fairly unique among wearables for being a clinical-grade electroencephalography (EEG) device, which means that, as well as being a consumer product, it is used by researchers to investigate everything from the diagnosis of stroke to treatments for obsessive compulsive disorder.

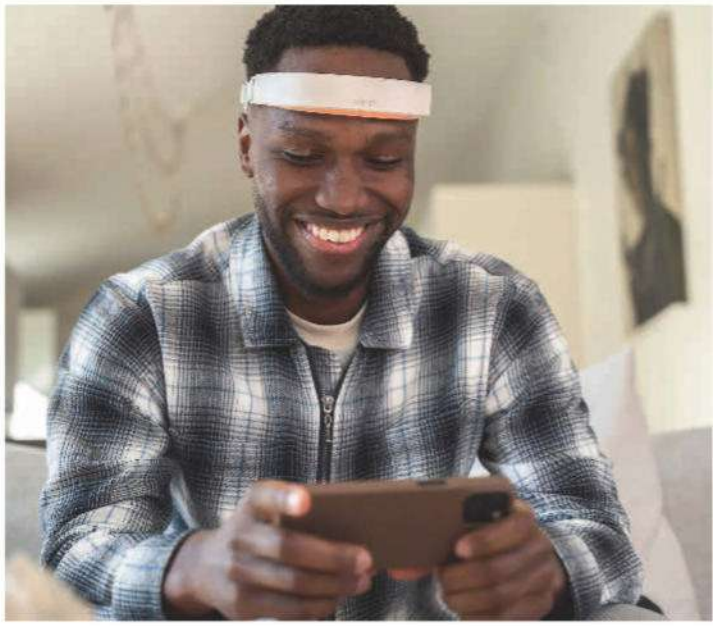
I try the Muse S. It's a simple set-up: the headband uses seven sensors to measure the brain's electrical activity together with your heart rate, breath rhythm and movement. This data is analysed and fed back to you via earphones. The device picks up neural oscillations, or brainwaves, with different frequencies corresponding with different mindsets. More alpha waves are associated with a relaxed, calm state. Beta waves are present when you are actively thinking about something, whereas delta waves are in abundance when you are in deep sleep.

At night, Muse analyses your brainwaves and uses responsive audio – guided meditation, sleep stories or soundscapes – to nudge you back to sleep when it recognises that you are waking up. During waking hours, Muse supposedly reduces stress and improves mood by providing live feedback to help you meditate.

I pop the device on my head and close my eyes. I immediately hear a loud wind blowing around me. When the Muse S registers brainwaves reflective of a meditative state, the wind dies down and birds start to chirp. "People who've never meditated before are like, 'Oh my god, what am I supposed to be doing?'" says Ariel Garten, a neuroscientist and co-founder of Muse. "We solved that problem by reading your brain activity and telling you when you're doing it right."

When my mind wanders, the birds fly away, and as my brain starts concerning itself with what time I need to leave the house, a storm starts rumbling. I refocus my attention and gradually manage to coax the odd twitter again. "You're getting this beautiful real-time feedback that lets you know that you are in the state of focused attention – you're meditating," says Garten. There was no doubt I felt more relaxed after each session, and I certainly got better at meditating over time, hearing just 11 birds on my first session and conjuring 46 on my last, five weeks later. But does the device, which costs around $300, really reduce stress and anxiety?

First, let's consider meditation itself. Although this topic isn't without controversies, in general, research suggests that meditation can have benefits. These include small improvements in our ability to control and monitor our behaviour when trying to reach a goal, potentially making us more productive, as well as some signs that it boosts attention and reduces anxiety, distress and negative mood. ›



MENDI.IO

The Mendi headset (near left) and the Apollo device (far left) aim to improve mental well-being

Muse itself has no shortage of studies that test its abilities – I was sent at least 50 by the company. On the positive side, most of these are independent, so shouldn't be biased. However, they are limited by being quite small or lacking a well-matched control. One small study that did have a control found that US school students aged 13 to 14 with behavioural problems who used Muse regularly showed improvements in behaviour compared with a group who didn't take part in any mindfulness training.

I also wasn't entirely clear on whether any observed effects are due to the technology itself. Would I see the same results if I merely sat quietly for the same amount of time?

Perhaps not. In an independent trial, 40 young adults with mild stress were split into two groups. One group received daily meditation training of up to 20 minutes for a month using Muse. The other group meditated for the same amount of time while listening to sounds like those provided by Muse, but without any real-time feedback on their mental state. Muse users showed greater improvements in stress tests and increased executive control – the ability to focus your attention where needed. They also displayed stronger brain activity associated with the relaxed mindset at the end of the experiment.

I asked Adrian Owen, a cognitive neuroscientist at Western University in Ontario, Canada, for his view of the device. He had recently completed a study of meditation, sleep and cognition using Muse. His paper, which is under peer review, shows that the Muse headband improved people's sleep quality by 20 per cent but had no direct effect on cognition. "I do think the device is a useful one," says Owen. "As a simple consumer neurofeedback device, I think it is one of the front-runners."

Other similar devices exist. I also tried the Mendi headset, which costs around $300 and employs a technique called functional near-infrared spectroscopy (fNIRS) to detect changes in the brain's blood flow and oxygenation in response to brain activity and uses that information to determine when you are calm and focused. Rather than feed that data back to you through birdsong, it translates it into the movement of a ball on your mobile device. My children preferred the Mendi because they found it easier to control a visual stimulus than an auditory one, whereas I liked closing my eyes while meditating and so preferred the Muse.

Like Muse, Mendi points to several studies that support its claims. However, the field of wearable fNIRS is young and there is a lack of large, gold-standard efficacy trials. One review of the field found that people can regulate their brain signals using fNIRS, which may enable them to reduce symptoms of anxiety, but it states that any conclusions about its clinical utility "are premature".

Nerve stimulation

Rather than massage the nervous system through meditation, other wearables aim to manipulate it through neuromodulation, where technology is used to alter nerve activity through direct or indirect stimulation. Take Nurosym, for example, a device that clips onto your tragus – the fleshy cartilage in front of your ear – and sends electrical messages towards the vagus nerve. Regular use of this device, according to its website, not only promises to reduce fatigue, depression and anxiety, but also to help treat long covid, improve heart health and more.

The vagus nerve has been getting a lot of attention lately. It is actually a pair of nerves that link the brainstem with several vital organs, controlling our involuntary functions such as breathing, digestion and immune response. It also plays a critical role in our parasympathetic nervous system, which governs the "rest and relax" activity that helps us recover after our sympathetic nervous system, or "fight and flight" responses, have kicked in during a period of stress.

In the 1980s, doctors targeted the vagus nerve by implanting electrical stimulators into the necks of people with epilepsy. The devices suppressed their seizures but also influenced their well-being. Since then, it has seemed as if stimulating the vagus nerve helps with every condition under the sun. "The vagus nerve is held up as a panacea because it is large and connected to a great many organs and systems. It can have an effect on everything from inflammation to cardiac control," says Benjamin Metcalfe at the University of Bath, UK, who has done some of the only experiments that have recorded electrical signals from within the vagus nerve directly.

According to Elisabetta Burchi, head of research at Parasym, the firm behind Nurosym, their device targets a branch of the vagus nerve that travels towards the brainstem to modulate parasympathetic activity, helping calm your immune response and reduce your stress.

In a small trial of 19 people with heart failure, those who received 4 hours of neuromodulation using Nurosym twice daily throughout their stay in hospital had reduced levels of inflammation and fewer signs of oxidative stress, which can damage cells, compared with those who received a sham treatment. A separate pilot study of 24 people with long covid saw decreases in anxiety, depression and fatigue after using Nurosym for 30 minutes twice daily for 10 days.

I was particularly interested in some small independent studies that showed how short sessions of around 5 minutes with Nurosym are associated with increased heart rate variability (HRV) – the variation over time of the period between consecutive heartbeats.

HRV is an increasingly well-respected marker of physical and mental health: exercise, a healthy diet and better sleep all help to increase it, whereas alcohol, chronic stress and poor sleep lower it. Low HRV is predictive of increased inflammation – known to be a precursor of many diseases, and of mortality in people with cardiac problems. Increasing it suggests that you may well be experiencing less stress. I used Nurosym

"You get real-time feedback that tells you that you're in a state of focused attention"

APOLLO NEUROSCIENCE

several times, but I found it uncomfortable to wear, so didn't feel motivated to use it for any length of time.

When it comes to vagus nerve stimulation, studies are mixed. "We are trying to generate more data, but there is still a long way to go," says Burchi.

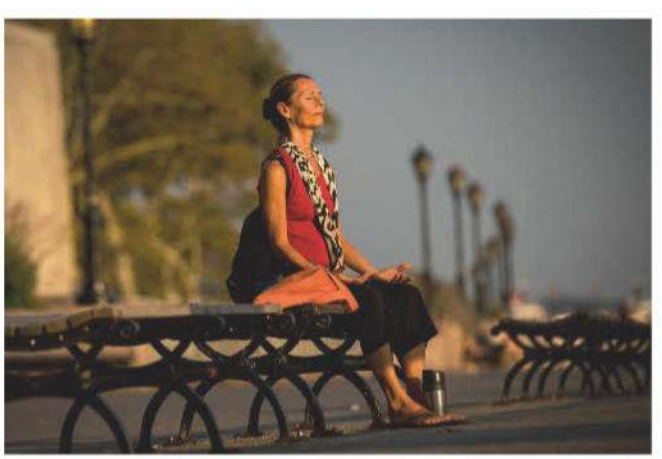
For now, Metcalfe remains unconvinced. He says there is no clear consensus as to whether non-invasive stimulation of the vagus nerve has any targeted benefit. He says his team has run several unpublished tests of non-invasive vagus stimulation with a range of devices and hasn't found any significant benefits. "I wish we had. It would make our research so much easier," he says.

Metcalfe explains that the vagus nerve is made up of 20 to 30 bundles of fibres called fascicles. Each tends to have a different job: one might control heart rate, another the immune system. Selecting one of the bundles is difficult even when you are implanting a stimulation device, he says, let alone when you are doing it non-invasively.

However, he suspects that a lot of vagus nerve devices probably show efficacy not through direct vagal modulation, but through up or down-regulating the nervous system via other pathways, such as the body merely responding to an unusual sensory input. Think of how you might pat a baby's bottom to lull it to sleep. "I think it is likely that you can achieve the same calming effect as stimulation simply through breathing exercises or meditation," says Metcalfe.

Speaking of unusual sensory input, I also trialled the Apollo, a wristband that uses vibrations to tackle stress, improve focus and increase sleep. The device, which costs around $350, tracks data such as HRV and provides different patterns of vibration depending on whether you are using it to relax or improve your focus. The exact patterns and frequencies are under wraps, as the company is applying for patents, but they generally felt like a gentle throbbing. They were pretty indistinguishable from one another, in my experience, and I am wary of claims made by the app that certain patterns can help you focus, feel energised, feel calm and promote several other states, having not seen any convincing evidence yet that vibration can modulate mood so specifically.

It is the patterns and frequency of the vibration that are key to its effects, says David Rabin, co-founder of Apollo Neuro. There is some early research suggesting that certain frequencies of vibration are able to modulate stress and anxiety levels. However, only one clinical trial of Apollo itself has been published, on people with systemic sclerosis, a painful autoimmune condition. Participants using the device for at least 15 minutes a day for four weeks showed a reduction in fatigue, as well as improved quality of life and fewer symptoms of depression.



REUTERS/BRENDAN MCDERMID

Meditation can reduce stress levels, but could wearable devices further enhance its benefits?

Rabin says that in unpublished trials, the device was also able to increase HRV and that it works by indirectly stimulating the vagus nerve, modulating parasympathetic activity.

Conscious of Metcalfe's criticisms of external vagal nerve devices, I ask Rabin whether he thinks the effects of Apollo might be replicated simply by practising breathing exercises or meditation. He says he has spent his entire medical career teaching people breathing exercises, but despite knowing they work to reduce stress, people just don't do them. "No matter how much we try to teach people, they forget to do it. And when they're stressed, they forget even more often," says Rabin." We've created a device that bypasses that process of calming yourself, because you can just strap it on and it does the work for you."

With no large, placebo-controlled trials of Apollo yet published, it is hard to reach any firm conclusions about it. Vibration technology is intriguing, though. There is some research suggesting vibration activates inhibitory interneurons, brain cells that are involved in the progression of mental health conditions, says Adriana LeGier at Grand View University in Iowa. Studies in rats also show that vibration can improve depression-like symptoms by protecting brain cells from destruction.

Scanning through the hundreds of devices on the market, I am a little overwhelmed with what to try next. Do I don the popular Oura ring, worn on a finger, that promises to track sleep's effect on my mental health, or start using the Nowatch, a screenless watch-like device that tracks my physiological data to help me monitor my stress?

None of these devices comes cheap, and with the industry in its youth, each has a long way to go to prove its worth. Personally, I will continue to use my meditation devices, if only because they motivate me to take moments of quiet. But I will keep watch on the field in the hope that some of this technology ultimately proves successful.

The more tools we have to help us live calmer, more focused lives, the better. ▮

New Scientist was given free trials of all the devices mentioned in this article.

Helen Thomson is a freelance writer based in London

"Mercury gets powerful solar storms every day"

Space scientist **Suzie Imber** tells Jonathan O'Callaghan about the violent solar winds that lash Mercury, how she hopes to solve some of the planet's many mysteries and her intense experiences with astronaut training

AS PLANETS go, Mercury is a world of extremes – and one that doesn't always make a great deal of sense. Its iron core is absurdly and inexplicably huge. Despite its searing temperature, it has ice trapped at its poles. It is also pummelled every day by wild solar storms – the likes of which Earth only experiences once a century.

Suzie Imber hopes she can help us get to know the planet a little better through her work as a co-investigator with Europe and Japan's BepiColombo mission, which last week made its final and closest flyby of Mercury, helping it to slow down before it enters orbit in 2026. Imber, based at the University of Leicester, UK, is an expert on space weather and says her studies of Mercury could help us prepare for the worst solar storms here on Earth. She was also, in 2017, the winner of the BBC's *Astronauts: Do you have what it takes?*, a gauntlet that pitted contestants against the rigours of space travel.

Imber told *New Scientist* why she is so excited about sending a mission to Mercury, what we hope to learn about this intriguing planet and whether she might one day venture out to the final frontier herself.

PAUL RYDING

Jonathan O'Callaghan: Why are we returning to Mercury now?

Suzie Imber: There are loads of reasons. From a high-level perspective, it's a pretty unexplored planet. We've had three flybys and one orbital mission – NASA's MESSENGER, which orbited between 2011 and 2015 – but the more we learn, the more questions come up. We think there's water ice deep in the permanently shadowed craters near the poles, but we don't know how it's still there. There seem to be some mystery substances called low-reflectance materials covering this ice; these appear to be carbon-based, but we don't fully understand them. It's also the only planet we know of that we think has contracted considerably.

You're saying Mercury has shrunk? Tell me more...

The MESSENGER mission discovered these interesting surface features called lobate scarps and wrinkle ridges that we don't see anywhere else. We think they formed as the planet's surface contracted in size, creating this bunching up of the surface rock. As far as we know, Mercury contracted a few kilometres in diameter. It doesn't sound like much for a planet nearly 5000 kilometres across, but it's quite considerable.

Your own particular interest is in space weather. Why is Mercury so fascinating from that perspective?

When we talk about space weather, we mean the "wind" of particles and magnetic fields streaming from the sun that washes over the planets. On Earth, if the conditions are right, this can cause problems with electrical systems. The worst-case space weather scenarios that we see on Earth – which can damage satellites and knock out power grids – happen once a century. But on Mercury you get extremely powerful solar storms every day. We're still trying to figure out what that does to the planet. It has a weak magnetic field, and it's very close to the sun. Is there a direct, observable effect on the surface? We're interested in whether that could be the case. And if you're wondering, by the way, there is an aurora on Mercury, but it's only visible in X-rays coming off the planet. ›

MARTIN HARVEY/ALAMY

Will studying space weather on Mercury teach us about similar phenomena on Earth?
The BepiColombo mission consists of two spacecraft; we'll have one close to the planet and one far away, so that we can get a measurement of the magnetic field close in and then at a greater distance. We'll see the solar wind, and then a few seconds later it'll hit the planet. So this will be like getting a view of an extreme example of the solar wind hitting Earth's magnetosphere.

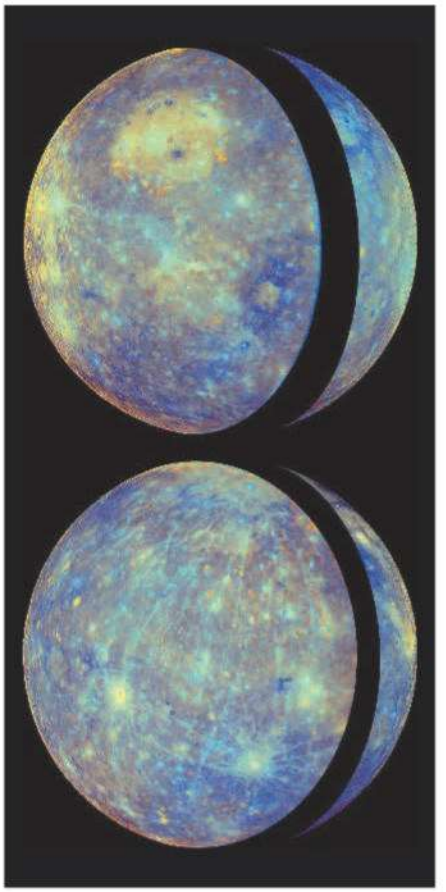
The physical process that drives space weather on Earth is called magnetic reconnection, where magnetic field lines store energy and momentum from the solar wind, which is then released and results in the aurora that we see. This process is the same on Mercury, but the rate is crazy. We're trying to understand the fundamental physics behind this solar wind-to-magnetosphere coupling. On Earth, the biggest space weather events happen so seldom that I'm never going to have a chance to measure one – though if one does happen it could be really catastrophic to our electronic infrastructure. So yes, by studying Mercury I'm trying to understand what would happen with a big space event on Earth.

Will the instruments you worked on help us solve any of the big mysteries about Mercury?
They might. The spacecraft has two special instruments, one of which we built at the University of Leicester called MIXS, the Mercury Imaging X-ray Spectrometer. One of these instruments points towards the sun, the other points towards the planet. The idea is that the sun gives off X-rays all the time, and when a solar X-ray hits the surface of the planet, it causes the surface layer of atoms to fluoresce. Our instrument picks up those X-rays and they can be used to tell us about the composition of the surface. This might help us unmask the identity of those mystery materials covering the ice at the poles.

Then there's this issue about Mercury's core. We know that Mercury's core is 85 per cent of its radius. That's massive; this planet is almost all core! For comparison, Earth's core is maybe 30 per cent of its radius. Why Mercury has so much core compared with the other planets is a really big open question, so we hope we'll get more information. One of the ways we're trying to work out what happened to Mercury is by using the ratio of different elements on the surface, like potassium and thorium, because this could help us deduce the collision history of the planet – in other words, what kinds of things have hit it in the past. That might help us figure out why Mercury looks the way it does.

So do we think Mercury might have been smashed about aeons ago?
There is a theory that it was originally much larger and some massive collisions early in its life blasted away the outer layers. That would explain the apparently oversized core. But other people suggest that perhaps it looks unusual because it actually formed somewhere else in the solar system and then migrated inwards. It has more metal than it has a right to given its size and location – but maybe that's because this isn't its original position. Part of the reason this has come up is because we often see planets around other stars in locations where they cannot have formed – so we know in principle that planets can move and migrate.

"Why Mercury has so much core compared with the other planets is an open question"



NASA/JPL

Suzie Imber studies the surface of Mercury (left) and climbs in the Andes (far left) in her spare time

Coming back down to Earth, tell me about competing in the BBC show *Astronauts: Do you have what it takes?* That must have been a wild ride.
I didn't know what to expect. In one of the tests, we had to take our own blood, and I'm pretty squeamish! Stabbing yourself in the arm is pretty stressful. There was a test to drive a Mars rover, which I massively failed at because I got the rover stuck in a cave. And there was a test where they submerged us in a swimming pool while inside a capsule that we had to escape from. Having a camera on you at all times for six weeks was interesting in its own right. We did over 40 challenges that spanned a huge range of disciplines, from psychology to fitness, teamwork to logical problem solving. We never knew what was coming and there was no feedback. It was a crazy experience!

But you won! How did it feel?
It was amazing. I wasn't the best at everything, but I won because I was a fairly steady pair of hands. At the end, I was convinced someone else was going to win. We were standing in a row and they announced my name, and I just absolutely froze. My jaw dropped and they had to film it again. I kept thinking I didn't do well in the tasks, so that gave me an interesting insight into my own psychology.

Would you go to space now?
If someone wants to buy me a ticket, I'd definitely go.

You've also been a high-altitude mountaineer for many years. Where have you climbed?
When you start climbing, you tend to start with popular mountains because you don't really know what you're doing. I started out in the Andes, and then I went to the Himalayas. I realized that I really enjoy complete remoteness, and I really don't like being in a situation like Everest, where there's a queue of people going up the mountain. So I started climbing more and more in the Andes.

I hear there was an algorithm involved at some stage...
I have access to a supercomputer here at the university. I asked some colleagues for a digital elevation model of the Andes and I wrote some code that would come up with a list of mountains over 5000 metres. There were dozens of unnamed and unclimbed peaks: there are 1042 mountains above 5000 metres in the Andes. So I started going to climb these unclimbed mountains.

How many have you bagged so far?
About 30 above 6000 metres and the same above 5000 metres. These mountains are difficult to get to and hard to climb, but sometimes we'd get to the summit and we'd find Incan remnants. The Inca had climbed these mountains and built small structures, little towers a metre high, and no one knows why they built them. We weren't the first to climb some of these after all. We'd get to the top and find the Inca had been there centuries ago, which is really cool.

When did you last climb one of these mountains in the Andes?
A few years ago. Covid put an end to it because there was no travelling. Then I joined mountain rescue as a volunteer, and now I spend a lot of my time living in the Peak District rescuing other people who've come to grief in the mountains. I'm putting those skills to good use.

Tell me more about the rescue side of things. It is worlds apart from studying Mercury.
We get called out up to 200 times a year. Last weekend, we had a girl who fell bouldering and almost ripped her foot off and someone who had a serious head injury in a really remote place. I mentioned I'm really squeamish, so the one thing I always try to do is think about the areas I need to improve. I wouldn't have believed it would be possible for me to deal with injuries like these, but now I'm much more confident. I love my job and I love studying Mercury, but I don't feel like I'm actively helping anybody. So it's a really meaningful thing to spend time doing. ▮

Jonathan O'Callaghan is a journalist based in the UK focusing on space

The back pages

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***Almost* the last word**
How do languages get their cases and declensions? p46

Tom Gauld for *New Scientist*
A cartoonist's take on the world p47

Feedback
Gamifying the pain of the research experience p48

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p48

The science of exercise

Sticking to it

Most people don't adhere to their New Year's fitness resolutions. Some well-researched tips can help change that, says **Grace Wade**

Grace Wade is a health reporter for *New Scientist* based in the US

WHETHER you are a couch potato or fitness aficionado, the start of a new year is a great time to set an exercise goal. The challenge, of course, is seeing it through. A 2020 study of more than 1000 people found that only about half of them sustained resolutions for a year. I, for one, have tried and failed for years to tick running a half-marathon off my bucket list. I am determined for 2025 to be different. So how do you set yourself up for success?

Well, to start, you may need to re-evaluate your resolution. Most guidance suggests establishing physical activity goals focused on achieving a certain outcome. Known as performance goals, these can include aims like walking 10,000 steps a day or, in my case, running a half-marathon.

However, a 2020 review suggests that people should only set a performance goal when they have the knowledge and resources to achieve it. Otherwise, outcome-based goals may actually hinder fitness ambitions. For instance, I called it quits on running last year after I tweaked my knee. If I had invested in a proper pair of shoes and learned the importance of mobility exercises, the injury probably could have been avoided.

This is why Christian Swann at Southern Cross University in Australia suggests that people, especially those new to working out, opt for learning goals rather than performance ones. The focus here is on developing strategies that are involved in performing a certain task. So, instead of aiming to walk 10,000 steps a day, you would find three new walking routes to enjoy.

ISLANDSTOCK/ALAMY

There are other things to consider when creating a fitness goal. A 2021 study monitored 250 people new to exercise. After one year, only about 17 per cent worked out at least twice a week. Three factors significantly increased their likelihood of doing so.

The first was enjoyment. People who found exercise fulfilling or pleasurable were 84 per cent more likely to work out regularly than those who didn't. Try different types of workout until you find one that you look forward to.

Commitment was also key. Participants who felt confident they would still exercise even when tired, working late or going through a stressful life event were 73 per cent more likely to regularly attend the gym. Making exercise a priority is crucial.

The third predictor was social support. Those who had friends or family who exercised with them or encouraged them to work out were 16 per cent more likely to become regular exercisers. So, ask your friends and family to hold you accountable.

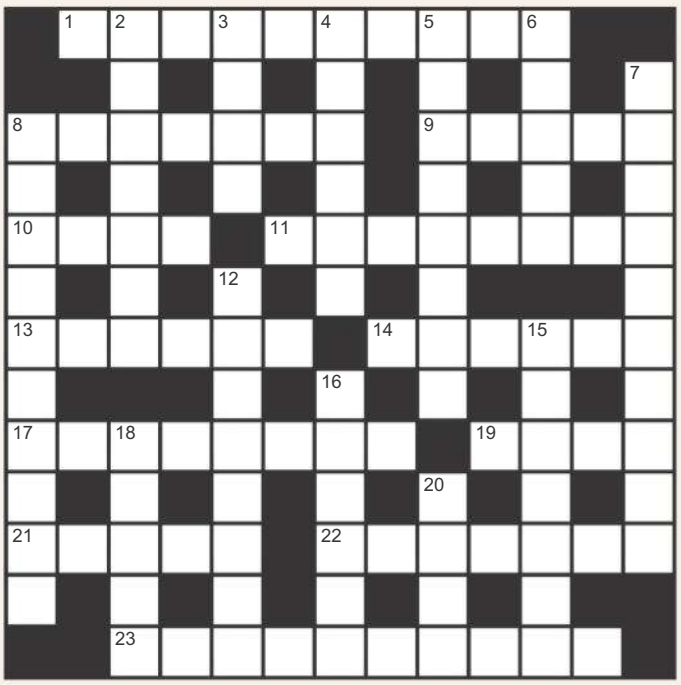
In summary, setting yourself up for successful fitness resolutions means choosing the right goal for you, making exercise fun, devising a plan to stick with it and finding social support. As for me, I am hoping that this year I will finally cross the finish line. ▮

The science of exercise appears monthly

Next week
Dear David

These articles are posted each week at newscientist.com/maker

Cryptic crossword #153 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Drummer backing riff at end of the Johnny Cash song (4,2,4)
8 Support an English fuel (7)
9 Herb grips tip of ratchet tool (5)
10 Returned no beer or spirit (4)
11 Salt drawn into treetop (8)
13 Administer olives providing certain lipid (6)
14 Alloy's weight borne by nobleman (6)
17 Hear ions disrupted natural filter (4,4)
19 Colour is able to set around end of day (4)
21 Wash off 20 per cent of reductants coating connections (5)
22 Crack licit as treatment for stress? (7)
23 Vehicle grazes decorative frames (10)

DOWN

2 Ignore a terrible period of human history (4,3)
3 Flipped toupee to cover a bean (4)
4 Magical realm beginning to fade north of a Great Lake (6)
5 Vulnerable type initially extinguished incense (2,6)
6 Old computer Sir Michael brought up (5)
7 Eavesdropper's botched royal plans (10)
8 Lowly workers accepting landowner's first polite remark (10)
12 County church approaches king for a spiral-shaped organ (8)
15 Dig for resources under your antiquated base (7)
16 Drive left one with big (not good) hairstyle (6)
18 Boy edges away from sick hedgehog (5)
20 Discuss replacing potassium with carbon powder (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #285
set by Corryn Wetzel

1 What is the largest internal organ in the human body?

2 What was the original nickname for the Google search engine?

3 What is the chemical symbol for gold?

4 Which cells in the pancreas produce insulin?

5 The Mars rover Opportunity operated for approximately how many Earth years?

Answers on page 47

BrainTwister
set by Katie Steckles

#56 Square sums by four

$1^2 = 1$, $1^2 + 2^2 = 5$ and $1^2 + 2^2 + 3^2 = 14$. If we continue in this way, when is the first time this sum is a multiple of 4?

If we added the squares of all the numbers from 1 to 20, what would the remainder be after dividing by 4?

What is the general pattern in the remainders for the sum of squares of the numbers from 1 to n? Can you explain why this occurs?

Solution next week

Amo amas amat

I can see how different grunts could come to mean "bear", "deer" or "run". But how do grammatically complex languages get their cases and declensions?

Paul Seedhouse
Newcastle upon Tyne, UK

This can best be answered from a broader perspective on the evolution of complex life and by understanding languages as complex, life-related systems.

All life on Earth began with our last universal common ancestor (LUCA), an organism similar to extant bacteria. Once life started, it evolved to become ever more diverse and complex, eventually developing the human brain, the most complex object ever found on Earth. The human brain co-evolved with the complex adaptive system of language to co-develop complex thought, technologies and societies. We cannot be sure for how long, but most estimates are for over 100,000 years.

As early *Homo sapiens* spread out around the world, they evolved and adapted in various ways to the new and changing environments they encountered. Their bodies adapted physically. For instance, people living at high altitude developed over time the ability to increase the amount of oxygen they acquired from thin air. Our ancestors also developed what we now call cultures in relation to new environments, for example by using new animal resources to develop new foodstuffs.

"As early *Homo sapiens* spread out around the world, they developed what we now call cultures in relation to new environments"

As part of the new cultures, they developed new languages in ways that seemed to them best suited to their new environments and societies. Around 7000 of these languages survive nowadays and there is astounding diversity in how they express and deliver the basic businesses of being human.

The questioner asks how grammatically-complex languages get their cases and declensions, which refers primarily to Indo-European languages. When these developed, their users found verb cases and declensions useful to deliver the specific businesses of their societies, cultures and belief systems – they embodied distinctions useful to them.

However, many other societies developed varieties of languages that managed human activities in their specific environments equally well, but via different linguistic means. For example, verbs don't decline or have cases in Thai or Chinese – both make use of tones instead.

It is as impossible for us to know why complex verb cases and declensions were so important for our Indo-European ancestors' societies around 6000 years ago as it would be for such an ancestor to understand our tweets today. However, the short answer is that languages co-evolve with societies.

A case in point is English, which has evolved to lose many of its cases and declensions and all of its grammatical genders. However, English is nonetheless able to adapt itself to new technologies and cultures and help us manage the complex business of being human in a digital world.

Graham Jones
Bridgham, Norfolk, UK

The regular structure of Latin and other historical and contemporary languages, with their genders, cases and declensions, suggests a degree of design. I suspect this happened as a mechanism for the elite to control the masses. The people who designed such languages had the time and support to learn the arbitrary grammars and master the delicate manipulations needed to write them. But I doubt that the written forms bore much relation to the spoken forms of the time.

However, language continued to evolve, allowing the masses to learn to read and write at the same time as growing food and fighting wars.

This evolution has reduced the arbitrary complexity of languages like the Latin I tried to learn at school in the 1960s. So, German retains masculine, feminine and neuter genders; French only has masculine and feminine; and English only uses gender as a grammatical concept in archaic forms such as the feminine names for ships. Grammatical cases are replaced by the use of prepositions or conjunctions to achieve almost all these functions.

In different regions, language has evolved differently, so American English still has "gotten" – a form that British English lost several centuries ago.

I think languages will continue to evolve and will converge to an international pidgin with a reduced vocabulary and negligible grammar.

ANDREW SEABY

A reader asks for help in identifying the shape of this curvy, sea-themed bowl

This week's new questions

Curvy object **Is there a term for the shape shown above: a smooth continuous curve with three axes of symmetry? And if anyone could share the equation for this curve, I would be very grateful.** ***Andrew Seaby****, Stroud, Gloucestershire, UK*

In the clouds **What happens to our electronic cloud records when we die?** ***Tony Spiess****, Taunton, Somerset, UK*

Those who remain

Why did crocodiles, turtles, lizards and birds survive the Cretaceous-Palaeogene extinction event, but non-avian dinosaurs didn't?

Mike Follows
Sutton Coldfield, West Midlands, UK

The Cretaceous-Paleogene (K-Pg) extinction event that occurred

Want to send us a question or answer?
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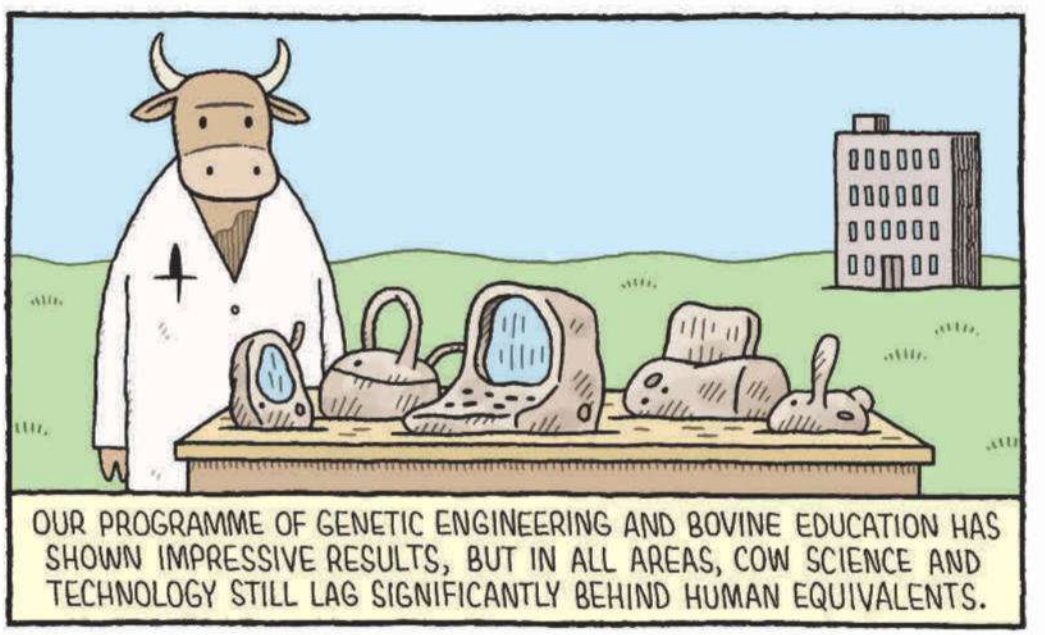
Tom Gauld
for New Scientist


OUR PROGRAMME OF GENETIC ENGINEERING AND BOVINE EDUCATION HAS SHOWN IMPRESSIVE RESULTS, BUT IN ALL AREAS, COW SCIENCE AND TECHNOLOGY STILL LAG SIGNIFICANTLY BEHIND HUMAN EQUIVALENTS.

66 million years ago is believed to have been caused by an asteroid crashing into Earth just off the Yucatan peninsula in south-eastern Mexico. The event caused catastrophic environmental changes, including firestorms, tsunamis, darkness from soot and dust, global cooling and ecosystem collapse.

While many species went extinct, certain groups were better adapted to survive. The survival of crocodiles, reptiles and avian theropod dinosaurs (the ancestors of modern birds) can be attributed to several key factors.

The asteroid impact would have lifted dust into the stratosphere, where it would have stayed for an extended period because this layer is above the weather systems and the rain that would normally carry it back down to the ground. With the dimming of the sun, photosynthesis would have been compromised, reducing the total biomass that could be supported on the planet.

Larger animals like non-avian dinosaurs required vast amounts

"After an asteroid hit Earth 66 million years ago, crocodiles and turtles would have been able to seek refuge in water"

of food and would have succumbed quite early to this disruption in food supply. Smaller species like crocodiles, lizards and birds had a distinct advantage.

Lizards could also shelter in burrows while firestorms raged above, and crocodiles and turtles could seek refuge in water, which would have buffered them from temperature extremes and atmospheric disruptions. Smaller species often reproduce faster, with shorter gestation periods, enabling them to generate larger populations and adapt more quickly to new conditions.

With a less specialised diet, avian dinosaurs could forage for a wider range of food and migrate to favourable habitats, helping them survive the extreme conditions of the period.

On the level

If Earth was flat, how would gravity manifest? (continued)

Guy Cox
Sydney, Australia

Gravity acts towards the centre of mass, so unless you are standing at the centre of a flat world, you won't land on the spot where you took off when you jump. Walking away from the centre will feel like walking uphill; walking towards the centre will feel like walking downhill. Organising sporting events would be tricky!

Mind you, it's very unlikely such a world could exist, since gravity tends to make planets spherical. About the only way it could be stable is if it were rotating rather fast, in which case the Coriolis effect might make walking in a straight line difficult – like those amusement park rides where you have to try to walk over a rotating platform. The Coriolis effect does occur on Earth, since it rotates, but only on a scale to affect things like large-scale weather patterns. ▮

Answers

Quick quiz #285 *Answers*

1 Liver
2 BackRub
3 Au
4 Beta cells
5 14

Quick crossword #174 *Answers*

ACROSS 8 Plough, **9** Whimbrel, **10** Tuff, **11** Laboratory, **12** Zinc, **13** Bluebottle, **17** Anoa, **18** Ratio, **19** Root, **21** Switchback, **23** Ergo, **24** Coelacanth, **28** Tens, **29** Fentanyl, **30** Ionise

DOWN 1 Illusion, **2** Surfactant, **3** Childbirth, **4** Swab, **5** Tier, **6** Abut, **7** Petrol, **14** Ultra, **15** Blockchain, **16** Turpentine, **20** Organism, **22** Woofer, **25** Late, **26** Cone, **27** Null

#55 Squares in squares *Solution*

As well as the original 9 by 9 frame holding a 3 by 3 photo, a set of 72 tiles can be used to make an 11 by 11 frame that holds a 7 by 7 photo, as $11^2 - 7^2 = 121 - 49 = 72$. A 19 by 19 frame that holds a 17 by 17 photo can also be made, because $19^2 - 17^2 = 72$. For square frames with a photo in the centre, the number of tiles needed will always be a multiple of 4. This can be shown by taking the frame size as a and the photo size as b, so the number of tiles is $a^2 - b^2$ or $(a - b)(a + b)$. Since the photo is in the centre, a and b must either be both odd or both even, so (a-b) and (a+b) are both even and their product is a multiple of 4. To determine the possible frames for any number of tiles, divide the number of tiles by 4 and find all the rectangles with that area.

Play your cards right

Readers in the northern hemisphere are facing many more weeks of long, dark nights and cold weather, so what could be better than a fun card game? If you're too cash-strapped for poker and have exhausted the comic potential of *Cards Against Humanity* (a state typically achieved after about 10 minutes of play), and if you have an interest in scientific research, you might want to consider *Publish or Perish*.

Created by social psychologist Max Hui Bai, *Publish or Perish* simulates the experience of building a career in scientific research. The game is to publish as many papers as possible and rack up citations – even if your papers are rubbish or you have to sabotage other players' publications. Or as Bai puts it: "Players race to publish useless nonsense while sabotaging each other and delivering snarky comments."

After releasing a beta version of the game for academics to try, Bai launched it on Kickstarter in late 2024, quickly racking up 5944 backers and $292,537 of funding. Those aren't Brandon Sanderson Four Secret Novels numbers, but that's still a lot of funding.

To publish a paper, players collect cards representing the key elements of a study, from ideas and data to references. To speed this up, you can use cards representing positive behaviours like going to workshops and forming collaborations.

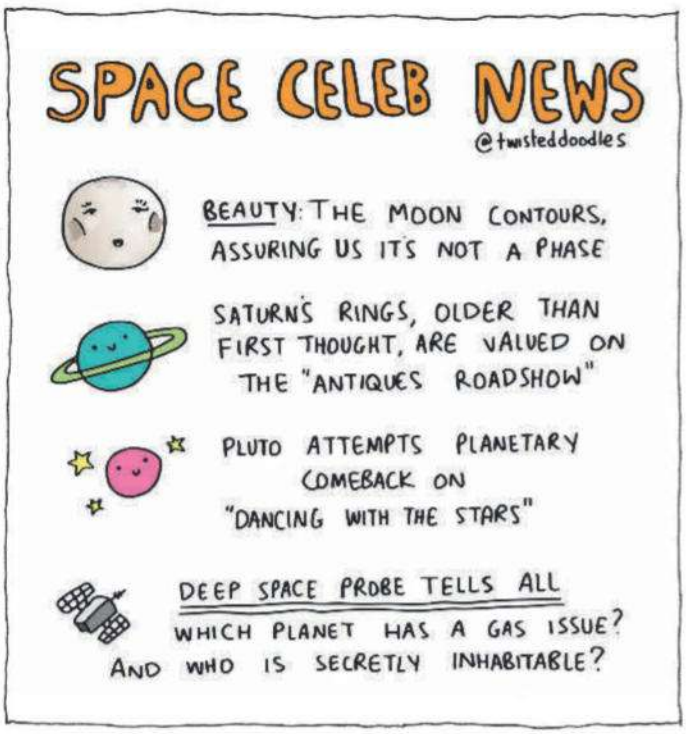
However, the real fun comes when you play dirty. Some cards enable dodgy practices like plagiarism and p-hacking (a statistical trick where you repeatedly reanalyse your data in different ways until you find a significant result, which you publish on its own). Others allow you to sabotage your opponents' "research", for instance by identifying a trivial citation error or calling for an audit of their work.

The game includes cards representing the papers you can publish, all of which have insane and frankly Feedback-adjacent headings like "Procrastination patterns among academics: A case study of myself" (by Anita Break, Psy.D) and "A practical field guide to unproductive meetings and organization time wastage" (by Max Time-Squander, MBA, J.D., M.D., Ph.D.).

Feedback doesn't have a copy – although now that this article is published, we feel it might be only a matter of time before Mrs Feedback or Feedback Jr gets it for our birthday. But as a (very) former academic researcher, we recognised the horror and pain of the research experience. We aren't sure what it would be like to play the game as an active researcher: it might be cathartic, but it might also resurface a lot of buried trauma. We suggest having a therapist on standby.

Feedback also wonders what the game's legacy will be. Famously, *Monopoly* was invented as a scathing satire on landlords and rentier capitalism – but after being purchased by Parker Brothers it was marketed worldwide as a fun game about how to get rich. Feedback wonders if in 50 years' time *Publish or Perish* will be sold by The Trump Organization as a fun game about how to discover new knowledge.

Twisteddoodles *for New Scientist*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Bots on parade

Just when you thought it couldn't get any harder to talk to actual loved ones (as opposed to advertisers and meme aggregators) on Facebook and Instagram, parent company Meta has decided to make it even more difficult.

It all began with an article in the *Financial Times*, in which Meta executive Connor Hayes was quoted saying that the company was going to add large numbers of AI profiles to the sites. Or as the *FT* put it: "Meta envisages social media filled with AI-generated users".

In the wake of this, many users noticed there actually already were a lot of AI profiles on the sites. According to Jason Koebler at 404 Media, these "Meta-controlled AI-generated Instagram and Facebook profiles... have been on the platform for well over a year". However, most of them had been deleted and the few that remained stopped posting in April 2024 – because "users almost universally ignored them".

Meta's failure to fully delete the profiles was a mistake, because users began experimenting. *Washington Post* columnist Karen Attiah had a chat with an AI called Liv, who was presented as a queer Black woman. Attiah got Liv to say none of its creators was Black, and only one out of 12 was a woman (though who knows if it was telling the truth or just hallucinating). Alas, Liv has since been deleted.

Meanwhile, *Business Insider*'s Katie Notopoulos pointed out that you can create an AI chatbot of your own in Facebook Messenger, and showed off one she had built: "Ciao! I'm Luigi, your go-to guy for all things healthcare inequality and reform... Getting involved in healthcare advocacy is my passion!"

Meta claims its next generation of AI profiles will be better. That doesn't sound difficult.

The real issue is why the firm thinks anyone would want this. The whole point of social media is to be able to talk to people, which is why social media platforms have spent so much effort clamping down on bots and spammers that pollute conversations.

Nevertheless, Feedback remains optimistic. It's entirely possible that the AI profiles project will go exactly as well as Meta's attempt to drag us all into the metaverse, which fell down when it couldn't create avatars with legs.

Or maybe the AI profiles can take on tackling misinformation, now Mark Zuckerberg has decided to fire all the fact-checkers.

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